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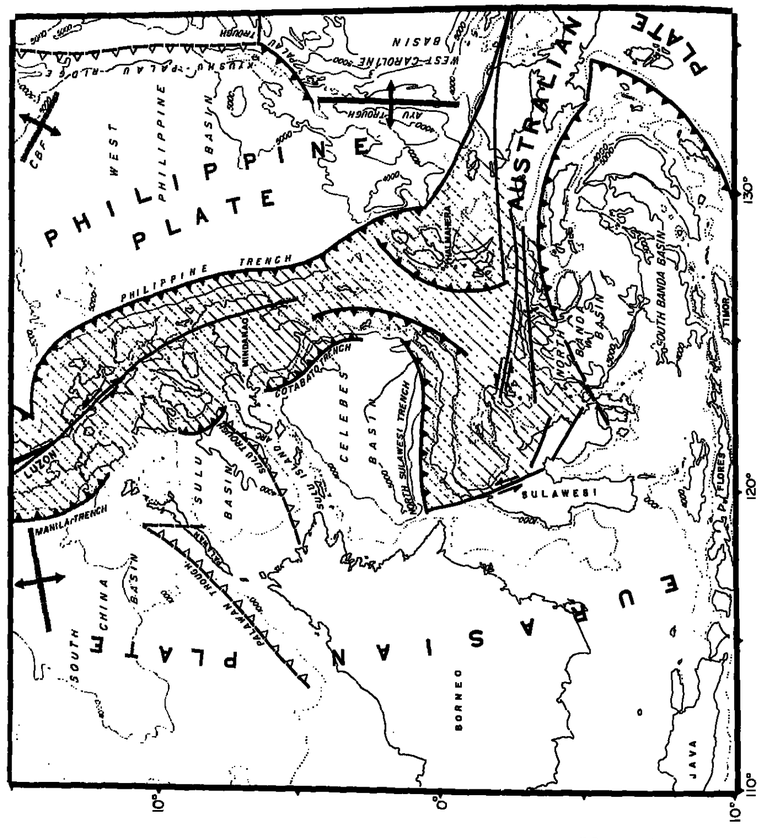

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'Gloria' Side-Scan Sonar in the East Pacific

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Introduction

The Institute of Oceanographic Sciences' long-range side-scan sonar 'Gloria' was operated over almost 20,000 km of ship track during the recent 56-day cruise 110 of *R.R.S. Discovery* in the eastern Pacific Ocean. The cruise took place between April and June 1980 and ran between Balboa (Panama), the East Pacific Rise, and Callao (Peru). The main objectives were geophysical studies of fast- and medium-spreading midocean ridges (including the Galapagos Triple Junction) and fracture zones, and the Peru Trench. This is the first time that this unique sonar has been used in the Pacific or on a fast-spreading midocean ridge.

Gloria provides very rapid physiographic surveys of large areas of the seafloor. As a result we obtained a wealth of new data and some very impressive views of the seafloor (see cover photograph).

This article briefly describes the cruise and presents some of our preliminary findings. We hope it will give a wide section of the scientific community a taste of the kind of data we obtain with Gloria, rapidly disseminate some of the new observations that we believe to be the most exciting, and bring to the awareness of others working in this area the existence of a new and unique data set.

Instrumentation and Data

The Gloria system has been described by *Somers et al.* [1978]. It is a towed, two-sided side-scan sonar that operates at 6.5-kHz acoustic frequency, with a maximum range of 30 km. It thus covers a swath of seafloor up to 60 km wide. In practice the range is limited by refraction of sound away from the seabed. The effect varies with the properties (mainly temperature) of the sea, and in the Pacific we were usually limited to ranges of about 20 km to either side of the track. Range resolution is about 50 m. The beam is about 2° wide in the fore-and-aft direction, so alongtrack resolution is about 1 km at maximum range, and improves at shorter ranges.

Gloria data are displayed in real-time on a dry-paper recorder and recorded on analog tape. The tapes are routinely replayed through a facsimile recorder, and prints from this are anamorphosed to produce a final record in which the slant range and alongtrack scales are equal. At present we display only slant range, not horizontal range, on a linear scale. This anamorphosed record is stored on 35-mm film negatives, from which prints, at any desired scale, can be made. For *Discovery* 110, all the records were mounted in their correct positions and orientations on charts at scales of 4 inches and 16 inches per degree of longitude.

We also used a second, hull-mounted sonar, which operates at 36 kHz. It has higher resolution than Gloria, but a more limited range. We were able to side-scan with it in water depths up to about 2.5 to 3.0 km, and it gave some indications of seafloor texture (e.g., outcrop versus sediment drape) in greater depths. We often operated it with one beam turned vertically down so that it behaved as an echo sounder with a broad beam athwartships but narrow beam in the fore-and-aft direction. This gives a very useful improvement over standard broad-beam echo sounders.

In addition to the sonars, the ship carried a suite of standard geophysical equipment comprising 10-kHz echo sounder, 2-kHz sub-bottom profiler (similar to a 3.5-kHz profiler), air guns, a single-channel seismic reflection profiler, proton magnetometer, and Lacoste & Romberg gravimeter. Satellite navigation was used throughout the cruise.

Ship's Route

Figure 1 shows the track followed by the ship, together with areas of detailed surveys. We crossed the following features during the course of the cruise: Panama continental margin, Panama Trench, Coiba Ridge and fracture zone, Cocos Ridge, Cocos-Nazca spreading center (95°W–102°W and 85°W–86°W), Galapagos Triple Junction, East Pacific Rise axis (2.5°N–4.0°S), Quebrada and Gofar fracture zones, Mendaña fracture zone (80°W–83°W), Peru Trench (10°S–14°S), Galapagos Rise, Bauer Scarp (9.5°S), and IPOD Leg 69 sites (Costa Rica Rift).

We collected Gloria and other geophysical data from all these features, and over most of the passage tracks in between.

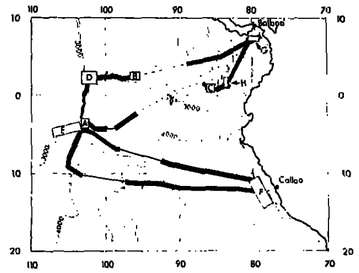

Fig. 1. Track chart of *R.R.S. Discovery*, cruise 110. Heavy lines—areas covered by Gloria side-scan sonar and other geophysical measurements; light lines—track with conventional geophysical measurements but without Gloria; broken lines—passage track with no geophysical measurements. Lettered boxes indicate areas of detailed surveys described in the text.

Study Areas

Below, we give brief descriptions of our preliminary findings and future plans for working up the data. Initials indicate the principal investigator in each case.

East Pacific Rise

A detailed survey in a 1° square was made on the rise axis near 3.5°S (A, Figure 1). The survey area includes the site of Lonsdale's (1977) Deeptow survey. Ship's track was oriented north-south, and track lines were spaced about 20 km apart, giving almost completely overlapping sonar cover with both east- and west-ranging sound beams. We also obtained an east-west narrow-beam echo-sounder profile to complement the Deeptow profile.

Preliminary results indicate that the tectonic pattern here is remarkably similar to that [*Laughton and Searle*, 1979] at slow-spreading ridges. Fault scarps predominantly face toward the spreading axis, have lengths of around 10 km, and are spaced about 2 km apart along flow lines.

Planned work on these data (R. C. S.) will (1) check in detail the apparent similarity with slow-spreading ridge fault patterns, (2) investigate the development of the fault pattern near the axis, and (3) make a detailed comparison with the Deeptow data.

Cocos-Nazca Spreading Center

A small survey was made of the 'propagating rift,' which *Hey et al.* [1980] have proposed exists near 95°W on the Cocos-Nazca spreading center (B, Figure 1). Gloria clearly showed a wedge-shaped section of new seafloor which appears to have been emplaced as the rift was propagating westward into older crust while the offset rift was dying back. The area of offset between the propagating and dying rifts is marked by oblique tectonic structures which we do not yet fully understand. A detailed new bathymetric chart of the area has been produced, and this, together with a tectonic description, is now being prepared for publication (R. C. S., and R. N. Hey, Hawaii Institute of Geophysics). A second propagating rift may have been observed on the same spreading axis near 99°W.

Another small survey of this medium-spreading plate boundary was made over the Galapagos spreading center at 86°W (C, Figure 1). We plan (R. C. S.) to compare the Gloria data here with the results obtained by the echosounder surveys of *Allmendinger and Riis* [1979] and the photographic surveys of *Van Andel and Ballard* [1979].

We find the medium-spreading Cocos-Nazca spreading center is characterized by the same tectonic pattern—2-km-spaced, inward-facing, normal fault scarps—as the fast- and slow-spreading ridges we have studied.

Galapagos Triple Junction (D, Figure 2)

This was the longest detailed survey carried out on the cruise. It lasted 3 days. An orthogonal grid of tracks with 20-km spacing was designed to allow Gloria to inscribe each spreading center from opposing directions, with tracks parallel to the spreading centers. The triple junction itself was viewed from all four directions (N, E, S, and W). Valuable records were also obtained with the hull-mounted sonar.

The tectonic pattern around the triple junction is rather complex, and careful study of all the data will be needed to elucidate it properly. However, at this stage we are confident of being able to recognize the positions of the main active spreading centers and of the boundaries between crust spread from different ridge axes. Analysis of these data will be carried out by R. C. S. and P. Lonsdale, Scripps Institution of Oceanography.

Quebrada-Gofar fracture zone area (T.J.G.F.)

Before the cruise, major fracture zones had been mapped at 3.5°S (Quebrada) and 5°S (Gofar). The precise nature and position of the plate boundary between them was unclear.

In this area (E, Figure 1) we ran several lines parallel to the Gofar and Quebrada fracture zones, four tracks oriented northeast-southwest to give full Gloria coverage of the area between the fracture zones, and a series of north-south oriented tracks (normal to the fracture zones) to obtain narrow-beam echo-sounder profiles across them through the use of the hull-mounted sonar.

It was discovered that another fracture zone exists between Quebrada and Gofar at 4°S. Following the convention for naming fracture zones in this area after the expeditions mapping them, we propose to call this the *Discovery* fracture zone.

We are now able to map out the precise position of the plate boundary between 3°S and 6°S. It consists of several short spreading sections offset by the fracture zones. Each of the three major fracture zones in this area contains up to four closely spaced parallel scarps within a zone some 30 km wide. We believe that in at least some of the fracture zones several transform faults are simultaneously active and that we can detect short spreading centers between some of these transforms.

In addition to our underway geophysical measurements, several ocean-bottom seismographs were laid in the Gofar fracture zone to study local seismicity.

Peru Trench (T. W. C. H.)

Nearly 3 days were spent surveying the Peru Trench between 10°S and 13.5°S (F, Figure 1). Previous studies of trenches have shown that graben form on the seafloor as the subducting plate bends downward [*Jones et al.*, 1978; *Schweller and Kulm*, 1978]. We wished to examine how these graben interact with the overriding plate and what influence they might have on the subduction or accretion of trench sediments. It is thought that such graben may provide a means of carrying sediment down with the subducting plate, provided the volume of sediments does not exceed that of the graben [*Hilde and Sharman*, 1978].

The graben were clearly defined in the Gloria sonographs, some extending nearly 100 km (Figure 2). They strike subparallel to the trench, and in roughly the same direction as the fault structures of the oceanic plate that were produced by spreading processes at the East Pacific Rise. However, they could be distinguished from the spreading fault structures by greater vertical displacement and horizontal separation, and a slightly different strike. Also, the spreading-produced fault blocks are predominantly tilted in one direction (faults dipping toward the midocean ridge axis), while these faults near the trench clearly dip both ways, forming graben.

Along most of the trench surveyed, the volume of sediment is greater than the volume of the graben, and the toe of the overriding plate is composed of folded, accreted sediment. The Gloria sonographs provided definitive evidence for the origin of the chaotic sedimentary structures commonly observed in trench axes at the base of the shoreward slope. Although lacking observable internal, coherent seismic reflection patterns, these structures are in this case, and probably many others, folded and faulted oceanic and trench deposits, and not slumps. Sonographs recorded during courses run subparallel to the trench, both seaward and shoreward of the axis, reveal that these features extend uninterrupted for tens of miles along the base of the shoreward trench wall.

Other features mapped include an echelon trench axis segments, apparently controlled by the graben fault structure of the subducting plate; extensive, long troughs and ridges on the middepth shoreward slope which strike roughly parallel to the trench; complex and possibly obducted structures in the shoreward slope where the Mendaña fracture zone intersects the trench; and an amazing paucity of canyons in the shoreward slope.

Panama Trench and Continental Margin (T. W. C. H.)

Our outward and return crossings of the Panama Trench (G, Figure 1) showed extensive folded sedimentary structures shoreward of the flat-lying sequence in the trench proper. These folded sediments could be seen from the sonographs to extend for about 100 km and to become more closely spaced as they curved to the northwest, suggesting that convergence has been from a westerly direction. High-resolution reflection profiles showed that the most recent trench sediments were being folded at the shoreward side.

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Cover. Long-range side-scan sonar image of a submarine volcano on the Nazca plate at 11°27'S, 84°52'W. The volcano is 10 km across at its base and has a 2-km diameter crater. Its summit stands some 1500 m above the regional 4300-m level of the seafloor.

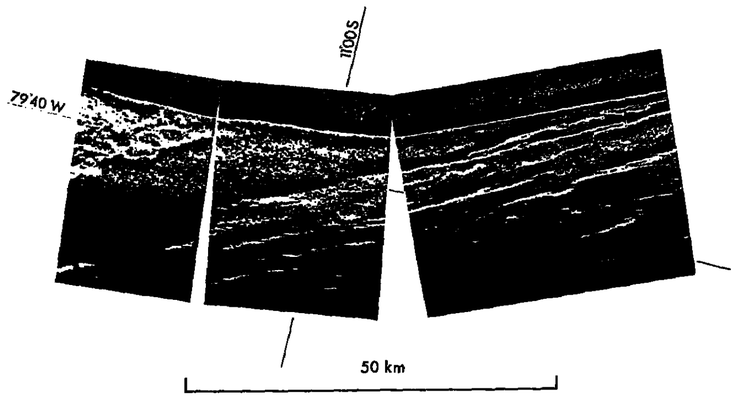

Fig. 2. Sonograph of part of the Peru Trench. Ship's track is along the top of the figure, and thus the direction of insonification is downward. North is to the left. The sonograph covers 30 km from top to bottom. The strong reflector near the top of the figure is the profile of the seabed immediately beneath the ship. Viewed thus, the sonograph appears to give an oblique view of the seafloor, with the subship profile as the horizon and the view from the Pacific toward South America. The mottled area in the upper left contains folded sediments of the lower inner slope. The lineations in the lower half of the record are fault scarps produced by normal faulting in the seaward plate as it bends over. The uniform grey area at center is the flat, turbidite-covered floor of the trench.

which indicates active convergence. The distribution of the folds indicates a small component of northern as well as eastward convergence for the oceanic plate. Northeastward dipping oceanic basement was observed in the air gun reflection profiles at more than 3.5 s beneath the folded sedimentary structures on the shoreward side of the Panama Trench. A large gravity low confirmed the presence of thick sediments in this structure. North of the trench, a ridge and associated linear structures striking about 080° were observed near 7° 10'N, from 78° 40'W to 80° 15'W. We think these structures may mark the site of a transform fault associated with the Caribbean/Nazca plate boundary.

Central Volcanos

Well over 100 central volcanos were observed during this cruise with Gloria. Their distribution is patchy: some regions contain none; in other regions we saw one or two isolated volcanos; and in two areas we saw large fields of them, with densities of around 10 per square degree. These fields were southwest of the Galapagos Islands and between the Galapagos Rise and Peru Trench. The fields are hundreds of kilometers across and do not have trends that are evident from our limited coverage.

The volcanos have a remarkably uniform morphology. They generally have steep (up to 45°) outer slopes and almost flat (but slightly convex) tops. Their basal diameters are 7–10 km, and their heights usually between 700 to 1000 m. Some have prominent central craters of about 2-km diameter. Forms that had a continuous cone up to the summit crater were seen (see cover photo), but they were rare. Occasionally several circular forms overlap, and complex craters containing several rings were also seen. The volcanos occur on seafloor of all ages. The youngest we saw had probably formed not more than a few kilometers from a spreading axis.

A detailed study of the morphology of these volcanos is in preparation (R. C. S.).

IPOD Leg 69 Sites

The sites of IPOD holes 501/504 and 505, south of the Costa Rica Rift, were covered by small Gloria surveys (H, Figure 1). The ship, steaming east or west, passed to the north and south of each site at a range of about 10 km (optimum for Gloria viewing). This pattern was designed to give optimum information on E–W faults outcropping near the sites, to assist in assessing the degree of hydrothermal convection occurring in these regions. Results have been prepared for publication in volume 69 of the *Initial Reports of the Deep-Sea Drilling Project* (R. C. S.).

Tectonic Fabric and Spreading History

Because of the relatively young crust and slow sedimentation rate, the tectonic fabric of the seafloor formed at the spreading axis remained visible to Gloria over the whole of our passages across the Nazca plate, and over much of the Cocos plate (Figure 3). Occasionally, old transform faults were seen, giving a direct determination of paleospreading directions. Moreover, throughout the plate the seafloor is characterized by linear, parallel ridges that are bounded by faults formed at and parallel to the spreading axis, so one can, in general, infer paleospreading directions to have been perpendicular to this observed topographic and tectonic fabric. A bonus is that these latter faults, on approaching a transform, always curve toward the offset ridge segment (*Searle, 1979*), giving additional information on the ancient disposition of the spreading axis.

Mammerickx et al. (1980) have recently suggested the existence of two distinct sets of extinct spreading ridges in the southeast Pacific. They believe that prior to 20 million years (Ma) before present the Pacific and Farallon plates in this region were generated at a northwest-trending spreading center, whose extinct axis is represented by the Mendoza Rise (20°S, 90°W). Between 20 and 18.5 Ma b.p., *Mammerickx et al.* (1980) postulate a major reorientation of plates, which results in the formation of a northeast-trending spreading center, the Galapagos Rise (11°S, 94°W). This in turn became extinct at 6.5 Ma b.p. when spreading passed to the present East Pacific Rise. Our data confirm a spreading axis trend of 341° in the eastern Nazca plate, as expected for crust formed at the Mendoza Rise. These trends extend at least as far as 92.5°W at 9°S (we have no data west of there at that latitude). At 11.5°S these trends extend as far west as 86°W. Between there and 91.5°W the tectonic trends change from NNW to NNE several times, but the new (Galapagos Rise) direction of 017° to 023° becomes firmly established by 91.7°W and continues to the end of the Gloria run at 97°W.

An analysis of spreading direction and former plate boundaries of the Panama Basin and Nazca plate is planned from the tectonic fabric observed in the sonographs recorded during the transit portions of the cruise (T. W. C. H. and R. C. S.).

Available Data

We have summarized above the areas of research which we are particularly interested in and intend to pursue. We expect the Gloria records especially, but also our other data, will be of value to others interested in this region who may be working on somewhat different topics. And in addition to their intrinsic scientific interest, we believe the Gloria data provide an invaluable guide to selecting sites for detailed geological studies.

All of our data will eventually (about 3 years time) be published in an IOS 'Cruise Data Report.' Anyone wishing to view or obtain copies of data from selected areas before that should contact one of the authors at IOS.

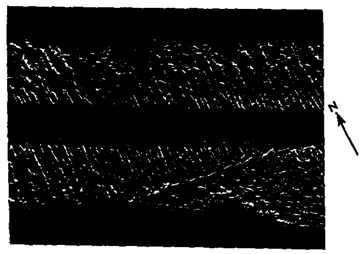

Fig. 3. Pair (port and starboard) of sonographs from the flank of the East Pacific Rise at 9°S, 104°W. The northern part of the area is dominated by N–S lineations, which are interpreted as west-dipping fault-scarps formed at and parallel to the East Pacific Rise spreading center. This lineated fabric is characteristic of much of the ocean floor. These scarps terminate against an E–W lineation that is the inactive trace of a previously unmapped transform fault. The northern N–S scarps bend westward just before they reach the transform, indicating that the transform offset is a dextral one. N–S scarps recur south of the transform, but are less clear, perhaps because the seafloor here is older.

Acknowledgements

We gratefully acknowledge the help of the master, officers, and crew of *R. R. S. Discovery*.

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Roger Searle was born in England, where he took a B.A. in natural sciences (majoring in physics) at Cambridge in 1966. He obtained his Ph.D. from the University of Newcastle-upon-Tyne in 1969, for geophysical studies of the East African Rift valleys. He subsequently lived in Ethiopia for 4 years while continuing those studies. While there, his interests were turned toward oceanography when he was invited to participate in a Woods Hole Oceanographic Institution cruise in the Red Sea.

In 1973, Searle joined the Institute of Oceanographic Sciences, where his main interests have been marine geophysical (particularly 'Gloria') studies of the tectonics of midocean ridge spreading centers and fracture zones.

After service in the Royal Navy, Tim Francis obtained his B.A. degree in physics and Ph.D. in geophysics from the University of Cambridge. He then worked for 2½ years at the Scripps Institution of Oceanography on the interpretation of seismic refraction data from the International Indian Ocean Expedition. Returning to England in 1967, he began work with the seismological group at Blacknest, making use of both teleseismic and ocean bottom seismograph data to study Mid-Atlantic Ridge earthquakes. His other research interests include resistivity measurements on the continental shelf and down *Glomar Challenger* drill holes in the ocean floor. Since 1979 he has headed the Marine Geophysics Group at the Institute of Oceanographic Sciences, Wormley.

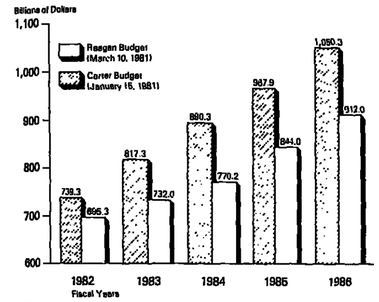
Thomas W. C. Hilde is an associate professor of oceanography and geophysics at Texas A & M University, College Station, Texas. There since 1977, he is also leader of Texas A & M's Geodynamics Research Program. He received his D.Sc. in geophysics from the University of Tokyo in 1974. Much of Hilde's research has been focused on the evolution of the Western Pacific and the Mesozoic crust of the Pacific Basin. During his early career, at Scripps Institution of Oceanography (1959–1967), he worked on the tectonic development of the Indian Ocean. Following 3 years with the Naval Oceanographic Office in San Diego (1967–1970), doing marine geophysical studies of the Western Pacific, he went to Taiwan, where from 1970–1973 he served as advisor to their government for development of a National Oceanographic Program. During the latter half of 1973 he was a visiting scientist at the Earthquake Research Institute of the University of Tokyo. From 1974 to 1976 he worked for the United Nations in Bangkok, Thailand, where he advised scientists from East Asian countries on their marine geophysical research and coordinated their participation in the Western Pacific International Decade of Ocean Exploration (IDOE) program, 'Studies of East Asian Tectonics and Resources.' He has been an active member, during the 1970's, of the International Geodynamics Project and is editor of the Geodynamics Project Western Pacific Final Report. He has served on the Ocean Crustal Dynamics Committee of Joint Oceanographic Institutions, Inc., is chairman of the Commission on Marine Geophysics of the International Association for the Physical Sciences of the Ocean, and is an associate member of the Commission for Marine Geology of the International Union of Geological Sciences. His present research includes high-resolution studies of trench tectonics and the factors influencing sediment subduction and/or accretion in convergence zones.

News

Reagan Finalizes Budget Cuts

As expected, President Reagan's revisions to the budget request made in January by then-President Carter slash R&D funds; most geophysics programs barely keep pace with inflation under the plan. Reagan had outlined proposed cuts in late February (*Eos*, March 3, p. 90) and on March 10 filled in the details and chopped an additional $13.8 billion from the total budget. Of the agencies and programs impacting geophysicists, the National Oceanic and Atmospheric Administration is probably the hardest hit, with a reduction of 24% from Carter's January proposals.

Total budget under the Reagan plan is $695.3 billion, down from Carter's proposed $739.3 billion (*Eos*, February 10, p. 49). Congressional action could alter the budget, however.



Total outlays, including Defense. (Source: Office of Management and Budget.)

NOAA

The Reagan budget request for natural resources and environment in fiscal 1982 is down to $7.9 billion from Carter's January request of $13.6 billion. Included in this is the axing of $200 million from NOAA.

Total budget for the agency was $1.05 billion in Carter's request. Reagan pared it by nearly 24% to $848.8 million, which is roughly equivalent to the fiscal 1981 appropriation. This means the end of the Coastal Zone Management Program, the Energy Impact Formula Grant Program, the Coastal Energy Impact Program (CEIP), the Sea Grant Program, undersea research, NOAA's LANDSAT plans, and the National Oceanic Satellite System (NOSS). In addition, NOAA will close 38 part-time weather service offices.

NASA

Reagan sliced $603 million from the January budget proposal for the National Aeronautics and Space Administration, bringing the agency's total budget to $6.12 billion. Eliminated from NASA's mission menu are funds for two interagency programs: the Geological Applications Program (GAP) and NOSS.

The revised budget preserves the space shuttle, although $36 million of the $2.2 billion allocated to the mission has been subtracted. This paring is offset by the addition of $60 million to the current fiscal year budget to allow for launch delays. The fleet of four orbiters will remain on schedule, but the option for a fifth shuttle orbiter remains open.

The Space Telescope will continue at the funding level identified in January ($119.5 million), as will the Galileo mission to Jupiter ($108 million) and the halogen occultation experiment ($7.5 million).

Venus Orbiting Imaging Radar (VOIR) is now scheduled for launch in 1988, a 2-year delay. Budgeted in January for $40 million, the revised budget funds it at $10 million.

Launch of the Gamma Ray Observatory (GRO) also will be delayed 2 years to 1988. The January request for GRO was $52 million; current request is $8 million.

Reagan's budget restructures the International Solar Polar Mission, scheduled for a 1985 launch. Fiscal 1982 funds are being deleted in Reagan's revised budget, but $5 million has been left to fund development of U.S. instruments that will fly on the European-built spacecraft.

Ocean Drilling

The National Science Foundation fared better than NOAA, although many programs will receive less money under the Reagan budget proposals than under Carter's budget. One of the programs trimmed is ocean drilling.

NSF's revised budget totals $1.03 billion, down from the $1.18 billion budgeted in the earlier request. The revised figure adds $20.5 million to the fiscal 1981 budget. As Reagan outlined in late February, all new starts are eliminated. These include the $75 million program to modernize laboratories and the $9.8 million for the 25-m, millimeter-wave telescope in Hawaii.

Ocean drilling was budgeted by Carter for $30 million: $14 million for the Deep Sea Drilling Program (DSDP) and $16 million for ocean margin drilling (OMD). Reagan's revisions pare the total to a $26 million contribution from NSF: $4 million will be cut from the OMD purse. This still represents a significant increase over 1981's $5 million budget.

The Astronomical, Atmospheric, Earth, and Ocean Sciences Directorate will show an 11% increase (to $253.1 million), over the fiscal 1981 budget in Reagan's proposal. This is a decrease of $14.9 million from the Carter proposal.

Antarctic research survives the pruning with the same amount ($70.1 million) as budgeted in January. This figure, however, does not keep pace with a 10% inflation rate.

USGS

Reagan's budget revisions prune the United States Geological Survey purse by $37.6 million—to $529.5 million. Most of the reductions were for proposed increases; few base programs will be touched, according to one USGS spokesman.

Cutbacks caused by the $37.6 million decrease from Carter's proposed budget include $1.9 million from the mapping program, $3.5 million for the development of assessment technology for the mineral resources program, $3.5 million from the oil shale program, $2.4 million from the geological framework program, and $500,000 from the regional aquifer system analysis program. Another $3 million will be cut from the earthquake program; this leaves an increase of $800,000 over the 1981 funding level.

Half a million dollars will be cut from the toxic waste/groundwater contamination program, $2.7 million from the coal hydrology program, and $7 million from the Outer Continental Shelf (OCS) resource evaluation program. The water-use program will continue at the 1981 level of funding and will not get the previously proposed $1.1 million increase. The oil shale program, including regulation, resource, and hydrology, will be cut by $3.5 million from the January proposals.

Two programs had been scheduled for start-up in the Carter fiscal 1982 budget but will be terminated under the Reagan plan. The cold hydrology program will be eliminated, as will geological studies on the engineering in OCS frontiers and on the evolution of the Atlantic margin.

Water Resources

Reagan proposes a 15% reduction in planned construction for water resources programs. About 75 of the more than 300 remaining programs would be delayed under the plan. Also proposed is the elimination of funding for the Water Resources Council (including state planning grants and the river basin commissions) and the Office of Water Research and Technology. However, an Office of Water Policy will be established within the Department of the Interior. This office will 'advise the Secretary on water resources policies,' according to the latest budget document.

The Reagan administration also proposes a $40-million reduction from the Carter budget in the Department of Energy's general science programs. The revised budget request for fiscal 1982 is $567 million.—*BTS* ⊠

Science Policy for the '80's

Science policy (if it ever was a policy) usually was to support ill-defined or 'basic' research in science; the 'policy' was embodied in the hope that supported research would someday pay off in the form of improved technology. One of the fathers of this policy during the post-WW-II period was Simon Ramo, a founding member of the National Academy of Engineering, chief scientist of United States ICBM defense operation, founder of the TRW Corporation, and now a member of President Reagan's science and technology task force. Simon Ramo represents an influential group dedicated to a 'systems analysis' approach to forecasting technological progress, and as such the 'systems' approach emerges as a central theme for science policy in the 1980's.

The new shift in national policy introduced by the Reagan administration includes revisions in science policy that have recently been termed as 'searching examination' (*Chemical & Engineering News*, Feb. 23, 1981, p. 22), 'Unkind cuts' (*New Scientist*, Feb. 12, 1981), and 'The Spectrum from Truth to Power' (*Science, Technology, and National Policy*, edited by T. Kuehn and A. Porter, Cornell University Press, Ithaca, N.Y., 1981). The idea now is to speed the conversion of scientific discovery into technology in an orderly way. As never before, there are growing debates over the roles of science in society, its lines of support, its applications. More than ever, social scientists, economists, and philosophical types are trying their hand at influencing science policy in very different ways than scientists themselves, as Vannevar Bush did 30 years ago.

A somewhat disjointed reaction has resulted from the melange of activity. There has been the incredible misunderstanding of the differences between 'real,' or basic, scientific research and 'development work,' or applied research, by the nonscientist science policy experts. Some of the misunderstanding has resulted from the combined concepts of 'R&D.' It would appear to be a simple matter of disconnecting pure science from technology, but unfortunately, basic science is a necessary supplier of the 'grist' for development and technology, so the misunderstandings will probably persist. A systematic, efficient approach to technology is needed to channel the huge amount of information and data for application to the enormous number of problems in society, many of which are immensely complex. In a recent, thought-provoking report (*Chemical & Engineering News*, sup.), Wil Lepkowski stated:

> Science policy issues leap out from everywhere. Reindustrialization of America. Innovation policy. Role of the White House science adviser. National agenda for the 1980's. The peer review system as an obstacle to new ideas. Global 2000. Deregulation. Risk analysis. Carbon dioxide and the threat to global climate. Impact assessment. Revamping the patent system. Five-Year Outlook for Science and Technology. Science indicators. Particle-beam weaponry. Weakness of military command and control systems. Obsolete instrumentation. Obsolescent professors. Technical manpower shortages. Everyday, federal agencies, universities, foundations, and think tanks pour out dozens of studies and reports on the measurements and ruminations of scientists and technologists.

Where neoconservatism enters the issues of science policy is in the now popular desire for the simple virtues of the competitive commercial market place. Industrial and economic growth involve advanced technology and engineering, and thus for a first step in the reaffirmation of these virtues it is perceived that U.S. industry itself should not be blamed for its decline in the late 1970's and early 1980's, but instead, big government and its policies are to blame. Lepkowski cites neoconservative science policy expert Simon Rottenberg, an economics professor at the University of Massachusetts, as reflecting new establishment thinking. According to Lepkowski

> [Rottenberg] says that the growth of science support by the government has corrupted quality in research and has produced off the bounty a 'socially excessive' mediocre class of scientist. Cutting basic research and training budgets, he believes, will weed out the less than competent scientists that infest academic research establishments.
>
> 'The central problem confronting public science policy [Rottenberg says] is that of avoidance of central direction. The judgment of those who make that policy is not better than the judgment of competitive commercial and intellectual markets. Where outcomes that would be generated by those markets are frustrated and dominated by taxes and subsidies that are implicit in science policy, policy will have done much mischief.'
>
> Thus, the National Science Foundation, the National Institutes of Health, and those other agencies that have supported basic research in universities have done mischief.

Lepkowski goes on to say that 'this new philosophy will not be comfortable reading to those accustomed to seeing science policy as the sum of budgets, the description of programs, and the organizational structure of NSF.'

As apart from the philosophy, the current practicability is seen in budget cutting to the 'bone' of the federal government. Science writer Dan Greenberg calls the cuts in science areas 'unkind,' because they appear to be heaviest in the social and behavioral sciences, which he favors as 'at least . . . pointed in the right direction' (*New Scientist*, sup.). There is continuing concern that the budget cutters are proceeding in the areas of R&D and science and technology without guidance of a White House science advisor. Very recently, reports have come from high officials in the Reagan administration that the need for a science advisor is being questioned, that the Office of Science and Technology Policy (OSTP) would not fit easily into the decision-making structure at the White House (*Science*, Mar. 6, 1981). It may be likely that the functions of the OSTP will be transferred to another agency and, thereby, will be made less effective. That the White House is proceeding with budget cuts and other science policy in the absence of a representative of the scientific community in the position of advisor has caused what is reported in *Nature* as 'scientific nailbiting in Washington.'

On the other hand, the school of systems analysts and systems engineers worry about the desperate need for information technology to keep our society from the ills of a rapid, uncontained information explosion (social 'entropy' is a term used loosely).

The influential figure in science policy, who himself comes from the scientific and the industrial worlds, is typified by Simon Ramo and other members of the task force. It is recalled that they have long supported strong government funding for R&D. It is also noted that they recognize the fragmented and piecemeal aspects of a federal government organization that is suffering from random growth in the pursuit of streams of information. Actually there is not a conflict between less structured support for basic scientific research and a simultaneous systems engineering approach to R&D, technology, and society's problems. The conflict seems to be drawn between the 'Simon Ramos' and the 'economist-social science policy expert-budget cutters.' The systems analysts believe in forecasting and prediction and in the utilization of a data base organized for the purpose.—*PMB* ⊠

Mt. St. Helens Has Little Weather Effect

Despite the ash spewed into the atmosphere, Mount St. Helens had less effect on the weather than might have been anticipated. The ash from the eruption had no effect upon precipitation and had a lower nitrate content than particulates in air samples unaffected by the fallout, according to recent reports by NOAA.

A team led by Rudolf Pueschel of the Air Resources Laboratories measured airborne particles and cloud droplets upwind and downwind of the volcano in April 1980. Down-

(News cont. on page 124.)

(News cont. from page 123)

wind, the mass of particles in the air was thousands of times greater, but the ash appeared to have no effect on the amount of water in clouds or the size of water droplets.

Laboratory tests of ash collected from the ground near Yakima, Wash., after the May 18 eruption, produced similar results. Russell Schnell simulated conditions in the volcano plume by squirting ash into an airtight plastic tent and allowing it to settle. At intervals, air samples were collected from the tent and particles were tested for their ability to serve as freezing, or ice, nuclei. The ash turned out to be a very poor source of ice nuclei. The effectiveness of an ice nucleus depends on the temperature at which it induces freezing in water cooled below the freezing point. The warmer the temperature, the more active the nucleus.

In the ash samples, very few nuclei were active at temperatures about 10°F. Even when the ash in the tent was three times thicker than a strong dust storm, no more ice nuclei were present than if there had been no ash at all.

Chemical analysis of the ash provided a clue to its meteorological harmlessness. Past research has shown that the cloud-modifying potential of man-made pollutants generally is linked to their content of water-soluble nitrates. The ash had less than the particles already present in the unpolluted air. The mineral-like ash proved highly insoluble.

Researchers are not calling Mount St. Helens insignificant; it injected millions of tons of dust and ash into the atmosphere. 'But as far as local weather is concerned, the volcano is relatively benign,' said Pueschel.—*PMB* ✻

New Earthquake Prediction Association

The Association for the Development of Earthquake Prediction (ADEP) was founded in January under the direction of Takahiro Hagiwara, a professor emeritus at the University of Tokyo. ADEP concerns itself with research related to earthquake prediction and prevention of earthquake disasters. It also aims to develop necessary technology to predict earthquakes and to help save lives and properties in Japan.

Although ADEP will concentrate mostly on Japanese earthquakes, the association will publish an international journal, *Earthquake Prediction Research*. Tsuneji Rikitake, chairman of IASPEI's Commission on Earthquake Prediction, will be the editor-in chief. D. Reidel Publishing Co. in the Netherlands will work with ADEP to publish the journal.

Geophysicists

J. F. Dewey has been named distinguished professor by the State University of New York at Albany. He also has been invited to give the 1981 William Smith Lecture to the Geological Society of London on 'The Plate Tectonic History of the British Islands.'

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Assistant Professor, Hydrology-Water Resources. Tenure track appointment involving teaching and research in hydrology and water resources. Excellent opportunities for interdisciplinary collaboration with ecologists, meteorologists, geologists and hydrologists. Please call or send resume, reprints, and names of three references to George M. Hornberger, Department of Environmental Sciences, Clark Hall, University of Virginia, Charlottesville, Virginia 22903

Closing date for applications April 15, 1981.

The University of Virginia is an Equal Opportunity Affirmative Action Employer.

Professor/Oceanography. The Department of Oceanography of Texas A&M University invites applications for an academic faculty position. The appointment is expected to be made at the level of professor in one of the major sections of the Department—biological oceanography, chemical oceanography, geological and geophysical oceanography, or physical oceanography.

Hence, applications are solicited from individuals who have demonstrated scholarship in research and teaching in any oceanographic subdiscipline. Outstanding applicants suitable for appointment to academic ranks other than professor will also be considered, but preference will be given to applicants suitable for appointment to the higher ranks.

To apply, or for further information, please contact Professor R. O. Reid, Head, Department of Oceanography, College Station, TX 77843 (713/845-7211).

Texas A&M University is an affirmative action/equal opportunity employer.

Stratigrapher, Leave of Absence Replacement. Applicants are invited to fill a position in stratigraphy-sedimentology beginning September 1, 1981. Ph.D. is preferred. We require an enthusiastic teacher to provide instruction in the above areas as well as historical and petroleum geology, with an interest of stimulating undergraduate research. This is a small department which emphasizes field studies and close work with students. Send resume, transcripts and reference letters to James F. Olmsted, Chairman, Department of Earth Sciences, Box 200, SUNY, Plattsburgh, NY 12901.

An EO/AA employer

Director Meteorology Division, Air Force Geophysics Laboratory. Air Force Geophysics Laboratory invites applications for the position of Director of the Meteorology Division located at Hanscom Air Force Base, Massachusetts. The Division is responsible for Air Force research and development in meteorology, atmospheric physics, remote and direct sensing technology, climatology, and relative technologies. The division director provides overall direction to an R&D program which employs over 80 people and covers a broad range of in-house and contractual scientific investigation. A candidate should have a record of distinguished achievement in meteorology/atmospheric physics as a research scientist and manager of a substantial R&D unit. This position is Air Force Senior Executive Service with a salary range of $52,247 to $57,673, subject to current $50,112 ceiling. For an application package, call collect: Robert Ellerin, (617) 861-2896. To be considered, applications must be returned by 30 April 1981.

Equal employment opportunity employer.

Princeton University/Scientific Programmers and Data Analysts. The Geophysical Fluid Dynamics Program of Princeton University seeks applicants for two full time scientific programming positions that may become available in July 1981. These programmers will become part of a research group that is making use of measurements of a variety of chemicals in the world oceans to learn about oceanic circulation and mixing. One position involves data analysis and the other involves developing computer simulations.

Applicants should have a bachelor's or master's degree in oceanography, physics, chemistry or engineering with a strong math background. Fortran programming and course work in oceanography are required.

Salary is $15,000 to $17,000 per year.

Send a resume, course transcript and names of 3 references to Prof. Jorge L. Sarmiento, Director, Geophysical Fluid Dynamics Program, Princeton University, Princeton, NJ 08544.

Princeton University is an equal opportunity/affirmative action employer M/F.

Faculty Appointment/Colorado State University. The Department of Earth Resources, Colorado State University invites applications for a tenure track appointment with emphasis on active research experience in remote sensing, and an interest in teaching graduate and undergraduate students beginning September 1981. The candidate is expected to have a Ph.D. degree in geology, watershed sciences or in a related field and is expected to develop and maintain a vigorous research program with special emphasis on the application of state-of-the-art remote sensing techniques to the investigation of natural resource phenomena. The candidate is expected to teach undergraduate and graduate courses in the application of remote sensing to natural resources.

Rank and salary are open and dependent on experience and qualifications of the applicant.

Applicants are invited to submit curriculum vitae, three letters of reference and a letter describing research and teaching interests to Dr. H. S. Boyne, Department of Earth Resources, Colorado State University, Fort Collins, Colorado 80523/(303) 491-5298.

Deadline for receipt of applications is April 15, 1981.

CSU is an EOE/AA. E.O. Office: 314 Student Serv. Bldg.

Faculty Position/University of Iowa. The Department of Physics and Astronomy anticipates one or two openings for tenure track faculty in August 1981. Research specialties for which substantial resources are available are magnetospheric and auroral physics and space and laboratory plasma physics, both theoretical and experimental. Other specialties of interest are astronomy, astrophysics, elementary particle physics, atomic physics, condensed matter, and low energy nuclear physics. The positions involve undergraduate and graduate teaching, guidance of research students, and personal research. Interested persons should send a résumé, a statement of research interests, and the names of three professional references to Search Committee, Department of Physics and Astronomy, University of Iowa, Iowa City, IA 52242.

The University of Iowa is an equal opportunity/affirmative action employer.

Tectonophysics. Seek half-time visiting professor for the academic year 1981–82 to teach course in regional tectonics and seminar of own choosing. Appointment is for half-time for entire academic year or full time for either fall or spring semester. Ph.D. required. Rank and salary negotiable. Inquiries to: Paul C. Hess, Chairman, Department of Geological Sciences, Brown University, Providence, RI 02912. Deadline for applications is May 31, 1981.

An equal opportunity and affirmative action employer.

Texas Tech University/Faculty Positions. The Department of Geosciences is seeking applications for additional faculty members in geology, geophysics and geochemistry; applicants from all fields of geology other than paleontology will be given serious consideration.

These are tenure track positions at the assistant professor level with appointments starting September 1, 1981.

Applicants must have completed their doctoral programs, be interested in teaching at both the undergraduate and graduate levels, and have specific plans for research in their fields of specialization.

Applicants for the positions should submit resumes, the names of at least three persons from whom the department may request letters of recommendation, and brief description of research interest to:

Donald R. Haragan, Chairman
Department of Geosciences
Texas Tech University
P.O. Box 4109
Lubbock, Texas 79409

Texas Tech University is an equal opportunity/affirmative action employer.

Chemical Oceanographer. Research associate, M.S., marine organic geochemistry and its relation to ocean productivity. Cooperative Institute of Marine and Atmospheric Sciences, University of Miami and National Oceanic and Atmospheric Administration, contact Chairman Search Committee, D. K. Atwood, NOAA/AOML, 15 Rickenbacker Causeway, Miami, FL 33149.

Hydrogeologist. Applications invited for a permanent faculty position. The position requires a Ph.D., teaching at graduate and undergraduate levels, supervision of research, and research in area of specialty. Interaction with faculty in surface water hydrology, stable-isotope geochemistry, geophysics, and sedimentary geochemistry is expected.

Candidates should send resume, statement of research interest, and addresses of three references to L. D. McGinnis, Chairman, Department of Geology, Northern Illinois University, DeKalb, IL 60115.

An equal opportunity/affirmative action employer.

National Science Foundation, Division of Ocean Drilling Programs: Deputy Division Director. NSF's Division of Ocean Drilling Programs is seeking qualified applicants for a permanent appointment as deputy division director. This position has a salary range of $44,547 to $50,112.50 per annum. The incumbent will augment and assist the division director in assigned managerial and program oversight activities to ensure that division operations are effective and within the context of approved program goals and related federal and NSF policies and procedures. He/she will formulate policy recommendations, develop long-range plans and budgets; supervise special studies; serve as division focal point for staffing and personnel division activities. Applicants should have an appropriate degree in the physical or engineering sciences, or the equivalent in experience, plus demonstrated experience in management of a large scientific project or field office. Applicants should send letters of interest and SF-171 or current resume to the National Science Foundation, Division of Personnel and Management, Personnel Administration Branch, 1800 G Street, N.W., Washington, D.C. 20550, Attn: Odessa G. White, Announcement No. EX 81–17. For further information call Odessa G. White–(202) 357-7840. Recruitment is open until position is filled.

An equal opportunity employer.

Geological or Mining Engineer. Geological or Mining Engineer with Ph.D., versatility and capability to integrate with geoscientists, oceanographers and ocean engineers. Permanent full-time teaching/research position with rank and salary open. Send resume and names of three references to: N. W. O'Hara, Head, Department of Oceanography & Ocean Engineering, Florida Institute of Technology, Melbourne, FL 32901 (305) 723-3701 x302.

Equal opportunity employer.

Petrology/Geochemistry, University of New Brunswick. The Department of Geology has a tenure track position available from 1 July, 1981, at assistant professor or higher level. The successful applicant will be expected to teach both undergraduates and graduates as well as carrying out research and supervising graduate students. This position is in addition to one currently advertised for a rock mechanic or geochemist.

The applicant should have a background in petrochemistry and petrology and should be prepared to teach in some aspects of petrology and geochemistry. The successful applicant will be responsible for supervision of analytical facilities including an X.R.F.

Applicants should have a Ph.D. and preferably post doctoral experience. Applications including a curriculum vitae and names of three referees should be sent to P. F. Williams, Chairman, Department of Geology, University of New Brunswick, Fredericton, N.B. E3B 5A3.

Purdue University. A tenure track appointment in the area of surveying and mapping. Undergraduate teaching in the areas of basic surveying, adjustment computations, and introductory photogrammetry/photo interpretation; involvement in teaching graduate level courses, and in existing and new research programs.

Preferential consideration to candidates with a Ph.D. and land surveying registration (or in the process of getting such degree and registration); rank and salary are open and depend on the experience and qualifications of the applicant.

Send resumes, by 15 April 1981, to Head, School of Civil Engineering, Purdue University, West Lafayette, IN 47907.

Purdue is an equal opportunity/affirmative action employer.

Postdoctoral Position/Earth and Space Sciences Institute, Tucson. To assist in analysis and interpretation of data from the Voyager Ultraviolet Spectrometer. Possible fields of research include the bound and extended atmospheres of Jupiter, Saturn, and Titan. Applicants should have a Ph.D. and expertise in several of the following areas: atmospheric physics, plasma physics, atmosphere-magnetosphere interactions, computer programming and simulation, and UV spectroscopy in the laboratory or space. Applicant should send resume, list of publications, and names of three references to Bill R. Sandel, Earth and Space Sciences Institute, University of Southern California, 3625 East Ajo Way, Tucson, AZ 85713.

USC is an equal opportunity/affirmative action employer.

South Dakota School of Mines & Technology. The Department of Geology and Geological Engineering anticipates two tenure track positions in economic geology beginning fall 1981. (1) Crystal chemistry/mineralogy/petrology of igneous and metamorphic rocks with emphasis on mineral deposits. (2) Geology of strata-bound or hydro-thermal deposits. Number one is at the full professor level, number two at the assistant or associate professor level. Please send resume and three letters of reference to Alvis Lisenbee, Department of Geology and Geological Engineering, South Dakota School of Mines & Technology, Rapid City, SD 57701 (605-394-2461).

South Dakota School of Mines is an equal opportunity/affirmative action employer.

Research Officer in Radiocarbon Research/Research School of Earth Sciences/Environmental Geochemistry Group, The Australian National University. The Environmental Geochemistry Group is currently using geochemical, stable isotope and radiochemical methods to study the geochemical evolution and paleoecology of the Great Barrier Reef, Australian inland lakes and the Gulf of Carpentaria. Applications are invited from scientists specialising in radiocarbon research to undertake collaborative studies in these projects and in aspects of Holocene paleoclimatology and the carbon cycle.

The appointee will normally be attached to the ANU Radiocarbon Laboratory and will work in collaboration and co-operation with its Head, H. Polach, and its staff. The appointee will be responsible for the expansion of the laboratory to meet the increased needs of the R.S.E.S. Environmental Geochemistry Program.

He/She is expected to independently conduct this research program, including the processing and counting of samples, and to contribute academically to their analysis, interpretation, and publication.

The appointment will be for three years in the first instance with the possibility of a continuing appointment after review. Appointment would be at the level of Research Officer Grade 1 although an appointment at Research Officer Grade 2 level would be considered for an appropriate applicant.

Salary on appointment will be in accordance with qualifications and experience within the following limits:

Research Officer Grade 1: $15,300–$19,125 p.a.
Research Officer Grade 2: $19,684–$23,622 p.a.

Further details of the post are available from Dr W. Compston, Research School of Earth Sciences.

Reasonable appointment expenses are paid. Return fares may be available to an appointee from overseas who holds a limited term appointment and assistance with accommodation will be provided to the successful applicant. The appointee will be required to undergo a medical examination.

Written applications, quoting reference number 81142; should be forwarded to the Secretary, The Australian National University, P.O. Box 4, Canberra. A.C.T., 2600, with whom applications close on 24 April 1981. Receipt of applications will not be acknowledged unless requested.

The University reserves the right not to make an appointment or to make an appointment by invitation at any time.

Research Fellow: Aqueous Solution Geochemistry. The Australian National University invites applications for appointment to the position of research fellow—aqueous solution geochemistry, in the Research School of Earth Sciences from those holding a Ph.D. degree in a relevant field.

The Research School of Earth Sciences has recently established an interdisciplinary research group in environmental geochemistry. Current areas of research include application of stable isotope studies and radiochemistry, to the geochemical evolution of the Great Barrier Reef, the Gulf of Carpentaria and the geochemical record contained in the sediments of Australian inland lakes. Special attention is also being devoted to holocene paleoclimatology and the carbon cycle. The group wishes to appoint a research fellow specializing in aqueous solution geochemistry to work on a collaborative basis on research projects in the above areas.

In addition to participating in collaborative research programs, the appointee will have the opportunity of pursuing independent research in general areas of interest to the group. The geochemical environment of Australian inland lakes and groundwaters is of particular interest and the appointee should be prepared to participate in a major research program aimed at understanding the solution, transport and precipitation of chemical species in heterogeneous aqueous solutions and sediments. A wide range of evaporate minerals are known to occur in these basins at the present time.

Consequently, the research undertaken by the successful applicant may have implications not only to environmental geochemistry and paleoclimatology but also to economically significant topics such as the mobilization, fixation and migration of metals and other elements of economic significance.

Applicants should have broad interests in geochemistry, together with a strong background in theoretical solution geochemistry and relevant experimental-chemical techniques. In addition to describing their qualifications, applicants are invited to submit research proposals detailing the general research directions and specific projects which they would wish to pursue. Further information concerning the position can be obtained directly from Dr. W. Compston.

Salary on appointment will be in accordance with qualifications and experience within the range: Research fellow $19,132–$24,972 per annum. Appointment will be for 2 or 3 years in the first instance with the possibility of extension to five years. Superannuation, housing assistance, reasonable appointment costs.

The University reserves the right not to make an appointment or to make an appointment by invitation at any time. No fixed closing date is specified for the above position.

Interested candidates are requested to submit their applications to The Registrar, Australian National University, PO Box 4, Canberra, ACT 2600, Australia.

Stanford University and San Jose State University: Atmospheric Sciences/Research Associate. Applications are invited for a position as research associate which will be available in June 1981. This position involves development of a three dimensional numerical planetary boundary layer model of the fate of large point source plumes in a coastal urban environment. Interested candidates with modeling experience and possessing the Ph.D. in atmospheric science, meteorology, or related areas are invited to submit a curriculum vitae and references to: Prof. Robert Street, Department of Civil Engineering, Stanford University, Stanford, CA 94305 or Prof. Robert Bornstein, Department of Meteorology, San Jose State University, San Jose, CA 95192.

Both universities are equal opportunity/affirmative action employers.

Sedimentary Geologist/Micropaleontologist, Washington University. The Department of Earth and Planetary Sciences, Washington University, has available a tenure track, assistant professorship position, beginning in the 1981–82 academic year for a geoscientist with research interests in diagenesis of sediments or in micropaleontology.

The successful candidate must have the following attributes: demonstrated creativity and promise of excellence in research and teaching; intent to develop a vigorous graduate research program; desire to teach courses in field of interest and related fields of geoscience at undergraduate and graduate levels.

Send resume, statement of future research interests, and names of at least three references, to Lany Haskin, Chairman, Department of Earth & Planetary Sciences, Washington University, St. Louis, MO 63130. Applications received through April 15, 1981.

Washington University is an equal opportunity/affirmative action employer.

Seismologist. The Department of Geology at the University of Illinois, Urbana-Champaign, has an opening for a tenure track position at the assistant professor level, beginning during the 1981–82 academic year. A Ph.D. is required. The applicant should have a strong background in geology, and post-doctorate experience is desirable. Candidates with interests and experience in tectonic studies based on seismological observations will be given preference. The successful candidate is expected to develop an active research program to complement existing programs in geodynamics, solid earth geophysics, and rock physics. There is also opportunity for interaction with programs in the Departments of Theoretical & Applied Mechanics and Civil Engineering, and the Interdisciplinary Materials Research Laboratory. Send resumé and names of three references to: Dr. John Hower, Head, Department of Geology, University of Illinois, 245 Natural History Bldg., 1301 W. Green St., Urbana, IL 61801 (Telephone: 217/333-3542). Applications should be received by April 15, 1981.

The University of Illinois is an affirmative action/equal opportunity employer.

Battelle, Pacific Northwest Laboratories. Applications are invited for a postdoctoral position in geophysics with emphasis on middle or upper atmospheric research at the Battelle Observatory in Richland, Washington. Stipend will be $18,000 initially; the position offers the possibility of permanent research position at the end of the postdoctoral appointment. Address inquiries to R.A. Stokes, Battelle Observatory, Battelle, Pacific Northwest Laboratories, P.O. Box 999, Richland, WA 99352.

Head: Earth Resources Branch, NASA/Goddard Space Flight Center. GS-1330-14/15: $27,871–$50,112 per annum, full-time permanent. The Earth Survey Applications Division, Applications Directorate, NASA/Goddard Space Flight Center invites applications for the open position of Head, Earth Resources Branch. The incumbent of this position is responsible for planning, managing, and conducting broad programs in earth resources remote sensing basic and applied research and data analysis, emphasizing the development and demonstration of applications of remote sensing of earth resources from earth orbiting satellites. The primary areas of research in the Branch are land use management, vegetation sciences including agriculture/forestry/rangeland and environmental monitoring utilizing remotely sensed data and advanced technologies. Also, significant effort is dedicated to sensor data evaluation in terms of applications and scientific utility, and to specification of data acquisition and information extraction systems which best meet user scientific and resource management needs. An advanced degree in earth or physical sciences is required with education in the vegetation sciences, land use or environmental monitoring being specifically preferred. Candidates should also have several years of progressively more responsible experience in the conduct, guidance and management of remote sensing research programs and clear evidence of a strong research background indicating senior research scientist stature.

Resumes/SF 171's should be sent to:
Dr. Robert D. Price, Assistant Chief
Earth Survey Applications Division
Code 920
Goddard Space Flight Center
Greenbelt, MD 20771
Deadline for applications is April 30, 1981.

Faculty Position in Physical Oceanography. The Department of Marine, Earth and Atmospheric Sciences at North Carolina State University invites applications for a nine-month, hard money, tenure track position at the assistant or associate professor level for a physical oceanographer, specializing in the numerical modeling of oceanic flows.

Applicants should have a strong background in geophysical fluid mechanics and the abilities to develop a funded research program and graduate level courses. Presently funded areas at NCSU include estuarine, coastal and deep-water oceanography.

Send curriculum vitae and the names of three references by March 31, 1981 to Professor G. S. Janowitz, Chairman, Search Committee in Physical Oceanography, Department of Marine, Earth and Atmospheric Sciences, North Carolina State University, P.O. Box 5068, Raleigh, NC 27650.

North Carolina State University is an equal opportunity/affirmative action employer.

Faculty Position in Oceanography/Geology/ University of Northern Colorado. The Department of Earth Sciences invites applications for a full-time, tenure track faculty position in oceanography, starting September 1981. We are seeking a person with a broad background in oceanography and one or more of the related earth science fields such as marine geology and/or sedimentology. Major responsibility will be teaching beginning and advanced courses in oceanography, courses in the related field, and general education courses. A modest amount of research is possible and is encouraged. Applicants should possess the Ph.D. degree or be in the final stages of completion of that degree. Starting rank and salary will depend on experience and other qualifications of the candidate selected.

Applicants should submit a resume and at least three letters of recommendation to Dr. L. Glen Cobb, Chairman, Department of Earth Sciences, University of Northern Colorado, Greeley, CO 80639.

The deadline for application is May 10.

Research Associate III. To be responsible for cruise logistics and programs to study pore water, nutrient, and trace metal chemistry, sea going work to collect pore water samples and analyze by autoanalyzer for nutrients; laboratory analysis of trace metals by mass spectrometry. Position requires precision to exceed that obtained by current atomic absorption spectrophotometric techniques and applicants should have developed a methodology to make measurements of ultra low levels of transition metals in sea water by solid source thermal ionization mass spectrometry. Position requires experience in and development of in situ recovery techniques for pore water samples of nutrients, transition metals and dissolved gases; data interpretation and publication. Ph.D. in chemical oceanography with experience in oceanographic cruises; experience in pore water sample collection methods for nutrients; experience with trace metals and dissolved gases by sediment squeezing; experience with centrifuge and in situ instrumental technique. Salary $21,000.00 per year, 40 hour work week. Please send resume to: Mr. R. Gray, Rhode Island Job Service, Washington County Government Center, Tower Hill Road, Wakefield, RI 02880, before April 3, 1981.

Geophysicist. Applications invited for a tenure track position at the assistant or associate professor level, beginning August 1981. Successful candidate will be expected to develop graduate courses in area of expertise and to teach undergraduate geophysics. Although all areas of geophysics will be considered, preference will be given to professionals with teaching and research interests in seismic stratigraphy and petroleum exploration.

Departmental equipment includes a refraction seismograph, resistivity meter, gravimeter, magnetometer, poremeter, and permameter. The candidate will have the opportunity to substantially add to his or her equipment needs.

Present computer facilities include a DEC 10 and an IBM 360-44, while a PK 3240 system with 16 megabytes capacity is under development.

ODU is a state-supported university serving nearly 15,000 students and is situated within the seventy Hampton Roads metropolitan area that is nationally known for its historic, recreational, and cultural facilities.

Salary commensurate with experience and qualifications. Send vitae, a brief discussion of research interest, and arrange to have three letters of reference by April 10, 1981 to Dennis A. Darby, Chairman, Department of Geophysical Sciences, Old Dominion University, Norfolk, VA 23508.

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Seismologist: University of Utah. The University of Utah is expanding its geophysics program in the Department of Geology and Geophysics by adding a tenure track faculty member in seismology at the assistant to associate professor level. Applicants with backgrounds and specialties in seismic imaging and theoretical seismology will be given preference. The individual will be expected to teach undergraduate and graduate courses, and to pursue an active research program with graduate students.

The department has modern teaching and research programs in geology and geophysics, and has close associations with the numerical analysis and data processing groups in computer science, electrical engineering, and mathematics. The geophysics component of the department has strong research and teaching programs in electrical and electromagnetic methods, thermal properties of the earth, potential fields, and seismology. Current research in seismology includes: earthquake research utilizing a new PDP 11/70 computer; monitoring of the Intermountain seismic belt by a 65 station telemetered network utilizing a new on-line PDP 11/34 computer; major experiments in seismic refraction and reflection profiling for crustal structure, and allied research in tectonophysics of mountain building.

The closing date for applications is May 1, 1981 and the appointment date is September 1981. However, the search may be extended if a suitable candidate is not selected, in which case applicants for a one-year visiting position for the academic year 1981–82 will also be considered.

A Ph.D. is required for this position.

Applicants should submit a vita, transcripts, a letter describing his/her research and teaching goals, and names of five persons for reference. Qualified persons should send their applications to William P. Nash, Chairman, Department of Geology and Geophysics, University of Utah, Salt Lake City, Utah 84112.

University of Utah is an equal opportunity/affirmative action employer.

Faculty Position/Synoptic Meteorology. The University of Maryland invites applications from qualified scientists for a tenure track faculty position at the assistant or associate professor level, commencing fall 1981. Candidates must have a Ph.D. in meteorology or related areas and have an area of specialization in synoptic and dynamic meteorology. Teaching experience is desirable. The successful candidate will be expected to teach primarily graduate level courses in synoptic meteorology and carry on an active research program. Salary will be commensurate with qualifications and experience.

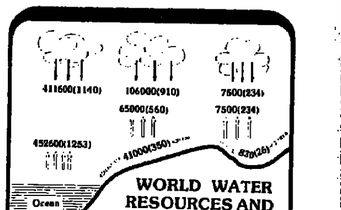
All applicants should send curriculum vitae, a brief statement of research interests and names, addresses and telephone numbers of three professional references to: Professor Ferdinand Baer, Chairman, Department of Meteorology, University of Maryland, College Park, Maryland 20742. Closing date for applications is April 15, 1981.

The University of Maryland is an equal opportunity/affirmative action employer

Physical Science. Tenure track assistant professor to teach physical science, geoscience and energy courses for non-science majors starting fall 1981. Background in physics and geoscience preferred. Applicants must have a well defined interest and experience in teaching non-science majors. A Ph.D. and an active interest in research is also required. Send curriculum vitae, three letters of reference, and a summary of research interests and needs by May 22 to R. Nackoney, Chairman, Department of Natural Science, Loyola University, Chicago, IL 60626.

EO/AAE.

Structural Geologist. The Department of Geosciences of Purdue University invites application for a tenure track faculty position in structural geology, starting in August 1981. Rank and salary will be commensurate with qualifications. A Ph.D. is required. The individual will be expected to teach undergraduate and graduate courses in structural geology and tectonics, participate in summer field courses, and pursue an active research program. Preference will be given to a candidate with an applied field orientation and a strong background in the quantitative analysis of field data. The department has active programs in petrology, geophysics, and engineering geology and has a close working relationship with the geotechnical group in civil engineering and the Laboratory for Applications of Remote Sensing. Closing date for application is April 1, 1981. Applicants should send a resume, the names, addresses, and telephone numbers of three referees, and a brief statement of research interests to R. H.



Three problems of major concern are covered in this book: the world water balance, world freshwater resources, and ways of solving the water problem based on the long-range forecasts of world water resources. Not only are theoretical aspects of hydrological science of concern but also discussions that will aid approach to practical problems.

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Professor/Chemical Oceanography. The Department of Oceanography of Texas A&M University invites applications for an academic faculty position. The appointment is expected to be made at the level of professor.

Hence, applications are solicited from individuals who have demonstrated scholarship in research and teaching. Outstanding applicants suitable for appointment to academic ranks other than professor will also be considered, but preference will be given to applicants suitable for appointment to the higher ranks.

To apply, or for further information, please contact Professor R. O. Reid, Head, Department of Oceanography, College Station, TX 77843 (713/845-7211).

Texas A&M University is an affirmative action/equal opportunity employer.

Exploration Geophysicist/University of Oklahoma. The School of Geology and Geophysics at the University of Oklahoma will hire an experienced exploration geophysicist to fill the Frank and Betty Schultz Professorship, and is seeking nominations and applications for the position. The person must be a distinguished scientist who has made important contributions to exploration geophysics through research. Preference will be given to a scientist whose specialty is seismic properties of earth materials and who has earned the Ph.D. The Schultz Professor will provide leadership and guidance in establishing a quality teaching and research exploration geophysics group. The University of Oklahoma has recently made a strong commitment to the earth sciences with the establishment of a College of Geosciences, to be housed in a new building. The School of Geology and Geophysics will expand from its present faculty of 16 to 25 faculty members by 1986. This will include three scientists in the exploration geophysics area, five in structure-tectonophysics-solid earth geophysics and others in stratigraphy-paleontology, geochemistry-petrology, and energy resources.

Applications are due April 30, 1981. Inquiries, nominations, and applications should be sent to John Wehan, Director, School of Geology and Geophysics, University of Oklahoma, Norman, OK 73019.

The University of Oklahoma is an equal opportunity employer.

Paleontologist. Seek half-time visiting professor for academic year 1981–82 to teach introductory course in paleontology and seminar of own choosing. Appointment is for half-time for entire academic year or full time for fall semester. Ph.D. required. Rank and salary negotiable. Inquiries to: Paul C. Hess, Chairman, Department of Geological Sciences, Brown University, Providence, RI 02912. Deadline for applications is May 31, 1981.

An equal opportunity and affirmative action employer.

Von Braun Post-Doctoral Fellowship in Space Physics/University of Alabama in Huntsville. Appointment effective September 1981 in a tenure track assistant professorship with reduced teaching load during the first two years. Research specialties in astrophysics, planetary science or solar terrestrial physics. Research support available from UAH, NASA and Redstone Arsenal. Salary competitive. Recent Ph.D.s are invited to send resume, research plans and names of four references. Apply to: Von Braun Fellowship Committee, Office of Academic Affairs, University of Alabama in Huntsville, AL 35899.

Equal opportunity in education and employment.

Northern Arizona University. Tenure track position in the department of physics. Presently planning early implementation of a masters degree program in atmospheric science. Candidate expected to contribute to research program. Teaching may be in undergraduate physics program as well as atmospheric science. Assistant or associate professor level. W. R. Wiese, Box 6010, Northern Arizona University, Flagstaff, AZ 86011.

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The National Center for Atmospheric Research in Boulder, Colorado has a position available immediately for a highly skilled person to manage the NCAR information office, whose responsibilities include receiving over 25,000 visitors annually at the NCAR laboratory, handling and initiating contacts with local and national media, and writing and distributing news releases and other informative material designed to generate national and local coverage of NCAR activities, goals, and achievements.

Necessary qualifications include demonstrated skill in science writing for lay and semi-technical readers, in dealing with representatives of national media and in managing a multi-faceted information function in a scientific setting. Please send letter and resume promptly to Dr. G. W. Curtis, P.O. Box 3000, Boulder, Colorado 80307.

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AGU

Sponsors of 1981 New Members

One hundred fifty-five new members were elected between January 1 and February 20, 1981. The AGU members who sponsored them are listed below.

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Two Members: Thomas J. Ahrens, Azher Ansari, David S. Chapman, Jared L. Cohon, Donald J. DePaolo, G. D. Garland, David J. Gorney, Darrell Henry, John R. Holloway, Bryan L. Isacks, David D. Jackson, Mark A. Jirsa, Steven R. Lipshie, Richard Lively, Lyle D. McGinnis, R. Meissner, Julio C. Olimpio, V. V. Palciauskas, Robert B. Smith, Richard G. Stearns, John S. Sumner, George A. Thompson, Karl K. Turekian, James A. Van Allen, Georges Weatherly, Harley L. Young.

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Meetings

Baltimore: A City Alive

It's a city rich with history, boasting the birth of the country's National Anthem in 1814. It's a city known for its scrumptious seafood, caught fresh from the Chesapeake Bay. And it's a city filled with charm that's evident everywhere you go.

For the visitor arriving into the dazzling Baltimore-Washington International Airport, it's only an 8-mile ride to the heart of the city, where all the excitement begins and where the beautiful new Convention Center stands, proud site of the first 1980 presidential debate.

Only two short blocks from the gleaming Convention Center is one of the city's most exciting new attractions, Harborplace. Located right on the water's edge, Harborplace offers any visitor the best in restaurants, shopping, window-shopping, casual eating, and strolling.

More than 11 formal restaurants allow visitors to dine in elegance while enjoying a variety of cuisines and the breathtaking vista of the city's waterfront. For the more casual dining in Harborplace, there are dozens of food emporiums, providing everything from fresh bay seafood to snacks and salads. Then, countless stores, boutiques, shops and stands will provide you with hours of browsing and shopping pleasure.

Harborplace is a two-pavilion wonderland, skirted by a red brick promenade which can take the stroller from the Maryland Science Center (home of the Davis Planetarium) to the pier of the *U.S.F. Constellation*, the oldest floating vessel of the United States Navy.

Still within easy walking distance of the Convention Center, the Civic Center, and Harborplace are four of the city's many hotels. Each provides lovely accommodations and a full complement of dining possibilities. But, if your tastebuds long to wander beyond the walls of where you're staying, Baltimore can truly offer something for everyone. The city's full of fine restaurants that offer excellent cuisine.

On a more cultural note, the Walters Art Gallery and the Baltimore Museum of Art display some of the most notable artistic collections in the country. Discover Matisse, Picasso, and Cezanne as you've never seen them, in the Museum of Art's famous Cone Collection, or go back to ancient Egypt or the Renaissance at the Walters. Both are open 6 days a week, year 'round, Tuesday through Sunday.

For theatrical entertainment, there's Center Stage and the Mechanic Theater, Baltimore's two largest theaters. Center Stage offers the finest in repertory theater and has started several of its first-rate productions on their road to Broadway. Equally professional and enjoyable, the Mechanic provides the best shows of Broadway in a much more accessible location. Both theaters are just minutes from the Convention Center.

History, not only of the city but of the country as well, is brought to life daily at some of Baltimore's historic attractions. Fort McHenry, home of the Star-Spangled Banner, is just minutes from the Civic and Convention centers and is open 7 days a week. The B & O Railroad Museum and the Mount Clare Station take any visitor back to the birth of railroading. The first passenger train operated from the Mount Clare Station, and some of the nation's most famous trains (including a replica of the Tom Thumb) are on display in the museum's Round House which can be visited any Wednesday through Sunday from 10:00 A.M. to 4:00 P.M.

With every hour of the day the city feels a little more vibrant and has a little more sparkle. The rebirth of an historic city into a dynamic, exciting, and charming waterfront city is being noticed all over the country. It's a city alive, a city on the move. And after you've seen Baltimore, you'll understand why she is known as the Treasure of the Chesapeake Bay.

Geothermal Petrology Workshop

The University of California at Riverside's Institute of Geophysics and Planetary Physics will sponsor a workshop on geothermal petrology and isotope chemistry June 25–26 at the university. Techniques, case histories, and laboratory demonstrations of petrology and isotope geochemistry applied to geothermal resource investigations will be included in the workshop.

For additional information, contact L. Lovell, Institute of Geophysics, University of California, Riverside, CA 92521 (telephone: 714/787-4501).

AGU 1981 Midwest Meeting: Call for Papers

The 1981 Midwest Meeting of the American Geophysical Union will be held September 17–18, in the Radisson Hotel, Minneapolis, Minnesota. Papers and posters originating in or pertaining to the region are solicited. Please send the abstract, by *July 1*, to AGU Midwest Meeting, 2000 Florida Avenue, N.W., Washington, D.C. 20009. Be sure to identify the session to which the abstract is being submitted so that it will be distributed to the appropriate chairman.

Session Topics

Mantle structure and dynamics. Contact Geoffrey Davies or Clem Chase.

Rock water interactions: Hydrothermal processes and metallogenesis. Contact William Seyfried.

Precambrian crustal evolution of the North American continent. Contact Paul Weiblen.

Geomagnetism and paleomagnetism. Contact Subir Banerjee.

Hydrology in the mid-continental U.S. Contact H. O. Pfannkuch or E. C. Alexander, Jr.

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Abstracts

Use standard AGU format (see page 20 of January 13 *EOS*) and send original and two copies of abstracts to AGU Midwest Meeting, 2000 Florida Avenue, N.W., Washington, D.C. 20009. Abstracts will be published in *Eos*, with a substantive meeting report after the meeting. There will be no abstract charge.

Travel Grants to IAGA and IAMAP Scientific Assemblies

Deadline for Applications: April 1

LAST

AGU has received from the National Science Foundation grants to assist the travel of individual U.S. scientists to the Fourth Scientific Assembly of the International Association of Geomagnetism and Aeronomy, to be held in Edinburgh, Scotland, August 3–15, 1981, and the Third Scientific Assembly of the International Association of Meteorology and Atmospheric Physics to be held in Hamburg, Germany, August 17–28, 1981. Application forms for the grants are available from:

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GAP

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Aeronomy

0430 Aeronomy Composition (atomic or molecular)
SPECTROSCOPIC MEASUREMENTS OF THE VERTICAL ABUNDANCE OF HYDROXYL (OH) IN THE EARTH'S ATMOSPHERE
Clyde R. Burnett (Dept. of Physics, Florida Atlantic University, Boca Raton, Florida 33431) and Elizabeth B. Burnett

Extensive new information on the daytime column abundance of atmospheric OH is presented from spectroscopic observations of sunlight absorption by the $P_1(1)$ $A\ ^2\Sigma^+ - X\ ^2\pi(0,0)$ transition of OH at 3081.7 Å, taken with a Pepsios spectrometer. The observations were made from the NOAA Aeronomy Observatory at Fritz Peak, Colorado between December 1976 and December 1979. An overall dependence on solar zenith angle, which controls the depth of penetration of the solar ultra-violet flux, is found with an overhead maximum abundance of $7.1 \times 10^{13} cm^{-2}$. This abundance and the solar zenith angle dependence agrees reasonably well with the predictions of several recent theoretical models and with the recent *in situ* measurements by J. Anderson. The average abundance increases by $1 \times 10^{13}/cm^2$ per year over the 1976–79 period. A seasonal variation of 30% from a spring maximum to a fall minimum was observed in 1978. A 35% diurnal oscillation in the 1978 data was discovered and shown to be solar flux dependent on both a diurnal and annual basis.
J. Geophys. Res., Green, Paper 1C0201

0430 Aeronomy: Composition (atomic or molecular)
SPECTROSCOPIC MEASUREMENTS OF THE VERTICAL COLUMN ABUNDANCE OF HYDROXYL (OH) IN THE EARTH'S ATMOSPHERE
Clyde R. Burnett (Dept. of Physics, Florida Atlantic University, Boca Raton, Florida 33431) and Elizabeth B. Burnett

Extensive new information on the daytime column abundance of atmospheric OH is presented from spectroscopic observations of sunlight absorption by the $P_1(1)$ $A\ ^2\Sigma^+ - X\ ^2\pi(0,0)$ transition of OH at 3081.7 Å, taken with a Pepsios spectrometer. The observations were made from the NOAA Aeronomy Observatory at Fritz Peak, Colorado between December 1976 and December 1979. An overall dependence on solar zenith angle, which controls the depth of penetration of the solar ultra-violet flux, is found with an overhead maximum abundance of $7.1 \times 10^{13} cm^{-2}$. This abundance and the solar zenith angle dependence agrees reasonably well with the predictions of several recent theoretical models and with the recent *in situ* measurements by J. Anderson. The average abundance increases by $1 \times 10^{13}/cm^2$ per year over the 1976–79 period. A seasonal variation of 30% from a spring maximum to a fall minimum was observed in 1978. A 35% diurnal oscillation in the 1978 data was discovered and shown to be solar flux dependent on both a diurnal and annual basis.
J. Geophys. Res., Green, Paper 1C0201

0430 Composition (atomic or molecular)
MEASUREMENT OF ATOMIC OXYGEN AND RELATED AIRGLOWS IN THE LOWER THERMOSPHERE
R.J. Thomas (Laboratory for Atmospheric and Space Physics, University of Colorado, Box 392, Boulder, Colorado 80309) and R.A. Young

Instruments on-board a sounding rocket were used to make simultaneous observations of atomic oxygen density and airglow emissions between 80 and 120 km. Atomic oxygen was measured with a resonance lamp and found to have a peak density of 6×10^{11} at 94 km. Similar structure is seen in the oxygen-density profile on both up- and downlegs. The following airglow emissions were measured using vertical-viewing photometers: Herzberg I bands near 300 nm; $O(^1S)$ green line at 557.7 nm; background at 566 nm; $O_2(^1\Delta)$ bands at 1.27 μm; and OH ($X^2\Pi$ Meinel) bands near 1.7 μm.
J. Geophys. Res., Green, Paper 1C0278

0430 Composition (atomic or molecular)
RECENT OBSERVATIONS OF HF AND HCl IN THE UPPER STRATOSPHERE
R. Zander (Institute of Astrophysics- University of Liège, B-4200 Liège-Ougrée, Belgium).

Concentrations of hydrofluoric- and hydrochloric acid have been determined in the upper stratosphere from near-infrared solar spectra recorded in the course of balloon flights from Palestine, Texas, USA. The results indicate an increase of the mixing ratio of HF between 30 and 37km altitude. The HCl mixing ratio was measured between 22 and 37km altitude; it increases by a factor of 3 in that altitude span. (Hydrofluoric acid, hydrochloric acid, infrared absorption, stratosphere).
Geophys. Res. Lett., Paper 1L0291

0430 Composition (atomic or molecular)
CONCENTRATION OF CARBON MONOXIDE IN THE UPPER STRATOSPHERE
R. Zander (Institute of Astrophysics - University of Liège, B-4200 Liège-Ougrée, Belgium) H. Leclercq and L.D. Kaplan

The concentration of carbon monoxide has been determined in the upper stratosphere from infrared solar spectra recorded by balloon in 1978 and 1979. The deduced CO mixing ratio increases with altitude; it has been found to be equal to $(1.0 \pm .25)\times10^{-8}$ ppv between 30.5 and 36.2 km, $(2.0 \pm .4)\times10^{-8}$ ppv from 36.2 to 41 km and about 4.0×10^{-8} ppv above 41 km. (Carbon monoxide, stratosphere)
Geophys. Res. Lett., Paper 1L0174

0450 Pressure, density, and temperature
NON-THERMAL EQUILIBRIUM BETWEEN ELECTRONS AND NEUTRALS AT IONOSPHERIC E-REGION HEIGHTS
S. Duhau (Departamento de Física, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, 1428, Buenos Aires, Argentina) and C. Azpiazu

The results of measurements of electron temperature in the E-region by incoherent scatter radar and Langmuir probes are contradictory. To provide an additional empirical evidence a correlation is found between the collision frequency data obtained by the method of deviative absorption and $F_{10.7}$ (for a height of 110 km) at noon. A remarkable agreement is found between these results and those obtained with the collision frequencies calculated from temperatures measured with probes on quiet days. We conclude that, contrary to what is usually assumed, electrons and neutrals are not in thermal equilibrium in the E-region, the quotient between the electron and neutral gas temperatures (T_e/T_n) depends strongly on $F_{10.7}$, and that there is a mechanism whereby electrons are heated, totally localized in the E-region.
Geophys. Res. Lett., Paper 1L0175

0460 Tides, waves and winds
LUNAR TIDES AT METEOR HEIGHTS
T. Tsuda (Ionosphere Research Laboratory, Kyoto University, Uji 611, Japan) J. Tsuji, T. Aso and S. Kato

We determined lunar semidiurnal (M_2) and diurnal luni-solar (O_1) tides of the meridional winds observed for two years between 1979 and 1980 by the Kyoto meteor radar. At 95 km altitude, the M_2 and O_1 tidal wind of 2.2 m/sec and 1.2 m/sec were observed. From the downward phase progression with altitude, the vertical wavelength was estimated as 60 and 25 km for the M_2 and O_1 component, respectively. Seasonal variation of the M_2 tidal wind was detected. Lunar variation has also been detected in the mean height of meteor echoes. The amplitude for the M_2 and O_1 component was 0.22 and 0.18 km, with the maximum height occurring at 9.4 and 14.1 hrs lunar time, respectively. (Meteor radar, Lunar tidal wind)
Geophys. Res. Lett., Paper 1L0069

Electromagnetics

0720 Electromagnetic theory
THE MAGNETIC FLUX LINKAGE OF A MOVING MEDIUM: A THEOREM AND GEOPHYSICAL APPLICATIONS
R. Hide (Geophysical Fluid Dynamics Laboratory, Meteorological Office, Bracknell, Berkshire RG12 2SZ., England, U.K.)

The time rate of change $\dot{N}(S,t)$ of the "number of intersections" $N(S,t)$ of the lines of force of a magnetic field $\mathbf{B}$ with a closed surface S satisfies a certain theorem. This leads directly to a necessary and sufficient condition for self-exciting hydromagnetic dynamo action (involving inductive interactions between $\mathbf{B}$ and fluid motions) in the electrically-conducting fluid "core" of a "planet", in terms of the structure of $\mathbf{B}$ at the core surface S_c. The condition shows the crucial importance of representing that structure with great accuracy in numerical or analytical models of dynamos and it suggests that dynamo action might be associated with certain topological properties of the pattern of the normal component of $\mathbf{B}$ on S_c. The condition also indicates that axisymmetric (but not necessarily steady) magnetic fields cannot be maintained by fluid motions; such fields must ultimately decay away, even in a compressible fluid (contrary to a recent claim in the literature to the contrary). The condition has to be modified when thermoelectric e.m.f's are present, but when these e.m.f's are proportional to $\mathbf{B}$ they cannot prevent the decay of axisymmetric magnetic fields. This result refutes a recent claim that such fields can be maintained by Nernst - Ettinghausen effects. The theorem for $\dot{N}(S,t)$ also shows that whilst fluctuations in $\mathbf{B}$ can take place on time-scales down to that (τ_c) associated with core motions (decades to centuries in the case of the Earth), the quantity $N(S_c;t)$ cannot change on time-scales shorter than the Ohmic decay time τ_d ($\gtrsim 10^4$ years). This result provides the basis of a method for solving the inverse problem of determining the radius of the core of the planet from observations of secular changes in $\mathbf{B}$ near the surface of the planet. The method has been applied to the Earth and Jupiter, with encouraging results.
J. Geophys. Res., Red, Paper 1B0363

0773 Remote sensing
A COMPARISON OF RADIATIVE TRANSFER MODELS FOR PREDICTING THE MICROWAVE EMISSION FROM SOILS
T. J. Schmugge (Hydrological Sciences Branch, Code 924, NASA/Goddard Space Flight Center, Greenbelt, Maryland 20771) and B. J. Choudhury

Two general types of numerical models for predicting microwave emission from soils are compared-coherent and noncoherent. In the former, radiation in the soil is treated coherently, and the boundary conditions on the electric fields across the layer boundaries are used to calculate the radiation intensity. In the latter, the radiation is assumed to be noncoherent, and the intensities of the radiation are considered directly. The results from the two approaches may be different because of the effects of interference, which can cause the transmitted intensity at the surface (i.e., emission) to be sometimes higher and sometimes lower for the coherent case than for the noncoherent case, depending on the relative phases of the reflected fields from the lower layers. This coupling between soil layers in the coherent models leads to greater soil moisture sampling depths observed with this type of model, and is the major difference that is found between the two types of models. In noncoherent models, the transmission at the surface is determined by the dielectric constant at the air/soil interface. The subsequent differences in the results are functions of both the frequency of the radiation being considered and the steepness of the moisture (i.e., dielectric) gradient near the surface. The calculations were performed at frequencies of 1.4 and 19.4 GHz and for two sets of soil profiles. Little difference was observed between the models at 19.4 GHz; and only at the lower frequency were differences apparent because of the greater soil moisture sampling depth at this frequency.

For those situations which have a nonuniform temperature profile, a definition for an effective emissivity is given; the ratio of brightness temperature to the effective radiating temperature. The latter being a weighted average temperature over the emitting depth.

Measurements from a tower are presented which show excellent agreement with the calculations from the coherent model. (Radiative transfer, soil moisture, remote sensing).
Rad. Sci., Paper 1S0437

0785 Tropospheric Propagation
PREDICTION OF ATTENUATION DUE TO RAINFALL ON EARTH-SPACE LINKS
G. Brussaard (ESTEC, Noordwijk, Netherlands)

A review is given of the current state of the art in the prediction of rainfall attenuation on slant paths. Different types of research effort are identified and discussed. A critical assessment of data analysis methods and theoretical models is made in order to identify areas where most effort is needed. Various types of data available are discussed (direct attenuation measurements, radiometric data, rain rate, radar reflectivity) as well as the models and methods available to date to relate these to attenuation on a satellite path. Finally, prediction methods for world-wide use are reviewed. (Satellite communication, radio propagation, attenuation, rainfall).
Rad. Sci., Paper 1S0149

0785 Tropospheric propagation
CLEAR-AIR PROPAGATION ON LINE-OF-SIGHT RADIO PATHS - A REVIEW
ERIK T. STEPHANSEN (INFT, Inc., The Technology Centre, Dept. TC-II, La Cours Vej 7, DK 2000 Copenhagen F, Denmark)

Progress in theoretical and experimental work on clear-air radio wave propagation is reviewed. Propagation on terrestrial and low elevation angle earth-space paths is treated. The emphasis is on an understanding of the physical propagation phenomena and their causes. Aspects related to radio systems are mentioned briefly. The variability in time and in space of the phenomena is pointed out with mention to the consequent influence on a modelling. The main items are absorption by atmospheric gases, multipath propagation on terrestrial paths, propagation via radio ducts, and phenomena related to low elevation angle earth-space propagation. 91 references.
Rad. Sci., Paper 1S0209

0785 Tropospheric propagation
PREDICTION OF ATTENUATION DUE TO RAINFALL ON TERRESTRIAL LINKS
F. Fedi (Fondazione Ugo Bordoni, Viale Trastevere 108, 00153 Roma, Italy)

In this review, attention is confined to rain attenuation and to its influence on the availability of terrestrial radiocommunication systems operating at frequencies above 10 GHz. The availability objectives recently established in the CCIR for digital systems, the information necessary and a calculation procedure applicable for system design are examined. Various methods for predicting attenuation due to rain are compared and reviewed. Present trends for the use of frequencies above 10 GHz in terrestrial systems are illustrated and areas in which further study is needed are indicated.
Rad. Sci., Paper 1S0195

0785 Tropospheric propagation
OBSERVATIONS OF CLOUD-PRODUCED AMPLITUDE SCINTILLATION ON 19 AND 28 GHz EARTH-SPACE PATHS
D. C. Cox (Bell Laboratories, Crawford Hill Laboratory, P.O. Box 400, Holmdel, NJ 07733) H. W. Arnold and H. H. Hoffman

The amplitudes of satellite signals sometimes scintillate ± several dB when heavy cumulus clouds pass through the radio path on hot summer days. These scintillations have been measured on a 19 GHz and 28 GHz earth-space path using 7-meter and 0.6-meter antennas at Crawford Hill, New Jersey. Scintillation intensity at 28 GHz is 1.2 times that at 19 GHz, consistent with the $f^{7/12}$ frequency dependence produced by a thin turbulent layer. The scintillation process is polarization-independent and has a low-pass power spectrum with a cutoff frequency of about 0.3 Hz. Rain attenuation often accompanies the more intense scintillation.

The mean duration of scintillation-produced fades is short (about 1.5 seconds for fades greater than 1 dB), but over 1000 fades of over 1 dB at 28 GHz were observed in two summer months. Because of their weak frequency dependence, these short but frequent events could produce repeated outages on 4 and 6 GHz earth-space links having low attenuation margins.
Rad. Sci., Paper 1S0196

0795 Tropospheric propagation
DEPOLARIZATION OF RADIO WAVES BY ATMOSPHERIC HYDROMETEORS IN EARTH-SPACE PATHS: A REVIEW
D. C. Cox (Bell Laboratories, Crawford Hill Laboratory, P.O. Box [illegible] Holmdel, NJ 07733)

Many measurements of earth-space radio-wave depolarization from 10 to 30 GHz have been made in recent years. This review relates the results from these measurements within the framework of theoretical relationships derived from rain and ice depolarization models. The review includes measured statistical relationships between depolarization and rain attenuation and contains cumulative statistics showing the relative frequencies of occurence of rain and ice depolarization.
Rad. Sci., Paper 1S0150

Exploration Geophysics

0910 Seismic methods
MIGRATION OF SEISMIC DATA FROM INHOMOGENEOUS MEDIA
See 0910 Computer applications
Leslie Hatton (Formerly Western Geophysical Co., Houston; presently Merlin Geophysical Co., Morris House, Commercial Way, Woking, Surrey, England) Kenneth L. Larner and Bruce S. Gibson

Because conventional time-migration algorithms are founded on the implicit assumption of locally lateral homogeneity, they leave events mispositioned when overburden velocity varies laterally. The ray-theoretical depth migration procedure of Hubral often can provide adequate first-order corrections for such position errors. Complex geologic structure, however, can so severely distort wavefronts that resulting time-migrated sections may be barely interpretable and thus not readily correctable. A more accurate, wave-theoretical approach to depth migration then becomes essential to image the subsurface properly. This approach, which transforms an unmigrated time section directly into migrated depth, more completely honors the wave equation for a medium in which variations in interval velocity and details of structural shape govern wave propagation. Where geologic structure is complicated, however, we usually lack an accurate velocity model. It is important, therefore, to understand the sensitivity of depth migration to velocity errors and, in particular, to assess whether it is justified to go to the added effort of doing depth migration.

We show a synthetic data example in which the wave-theoretical approach to depth migration properly images deep reflections that are poorly resolved and left distorted by either time migration or ray-theoretical depth migration. These imaging results are, moreover, surprisingly insensitive to errors introduced into the velocity model. Application to one field data example demonstrates the superior treatment of amplitude and waveform by wave-theoretical depth migration. In a second data example, deep reflections are so influenced by anomalous overburden structure that the only valid alternative to performing wave theoretical depth migration is simply to convert the unmigrated data to depth.

When the overburden is laterally variable, conventional time migration of unstacked data can be as destructive to steeply dipping reflections as is CDP stacking prior to migration. A schematic example illustrates that when migration of unstacked data is judged necessary, it should normally be performed as a depth migration.
Geophysics, Vol. 46, No. 5

0930 Seismic methods
THE INVERSE PROBLEM OF THE SHEAR MODULUS AND DENSITY PROFILES OF A LAYERED EARTH
S. Coen (Department of Materials Science and Mineral Engineering, University of California, Berkeley, CA, 94720)

It is shown that the shear modulus and density profiles of a layered earth are uniquely determined from the surface displacement due to an impulsive SH line source. Two analytical examples are given which reconstruct these profiles from an analytic surface data. (Inverse scattering, elastic profiles).
J. Geophys. Res., Red, Paper 1B0162

Geochemistry

1410 Chemistry of the atmosphere
LONG WAVELENGTH CARBONYL SULFIDE PHOTODISSOCIATION AND THE STRATOSPHERIC SULFUR CYCLE
R.P. Turco (R & D Associates, Marina del Rey, CA 90291) R.J. Cicerone, E.C.Y. Inn and L.A. Capone

The aeronomic implications of a preliminary observation of weak OCS photoabsorption above 270 nm are investigated. It is argued that the measured cross section is consistent with a forbidden transition in this wavelength region. Model calculations are made for the OCS photodissociation rates in daylight, the OCS and SO_2 distributions in the upper atmosphere, and the budgets of sulfur in the stratosphere and OCS in the troposphere, assuming various extrapolations of the measured OCS absorption cross sections and quantum yields to longer wavelengths. It is shown that weak OCS absorption above 300 nm can have important consequences for all of these quantities. Laboratory and field experiments are identified which might lead to a better understanding of the atmospheric OCS cycle.
J. Geophys. Res., Green, Paper 1C0[illegible]

1410 Chemistry of the atmosphere
[illegible]
Geophys. Res. Lett., Paper 1L0173

1410 Chemistry of the atmosphere
VERTICAL PROFILES OF ETHANE AND PROPANE IN THE STRATOSPHERE
J. Rudolph (Institut für Chemie: Atmosphärische Chemie, Kernforschungsanlage Jülich GmbH, Postfach 1913, D-5170 Jülich, FRG) D.H. Ehhalt, A. Toennissen

Stratospheric measurements of the C_2H_6 mixing ratio up to 30 km, and of the C_3H_8 mixing ratio up to 18 km altitude are reported. The observed vertical gradient of C_2H_6 is much weaker than that calculated from a 1-D steady state model, indicating lower concentrations of atomic chlorine in the lower stratosphere than predicted by models. From the measured C_2H_6 profile a tentative estimate for the Cl concentration is derived. (Stratospheric ethane measurements, stratospheric propane measurements, Cl-radical profiles).
J. Geophys. Res., Green, Paper 1C0467

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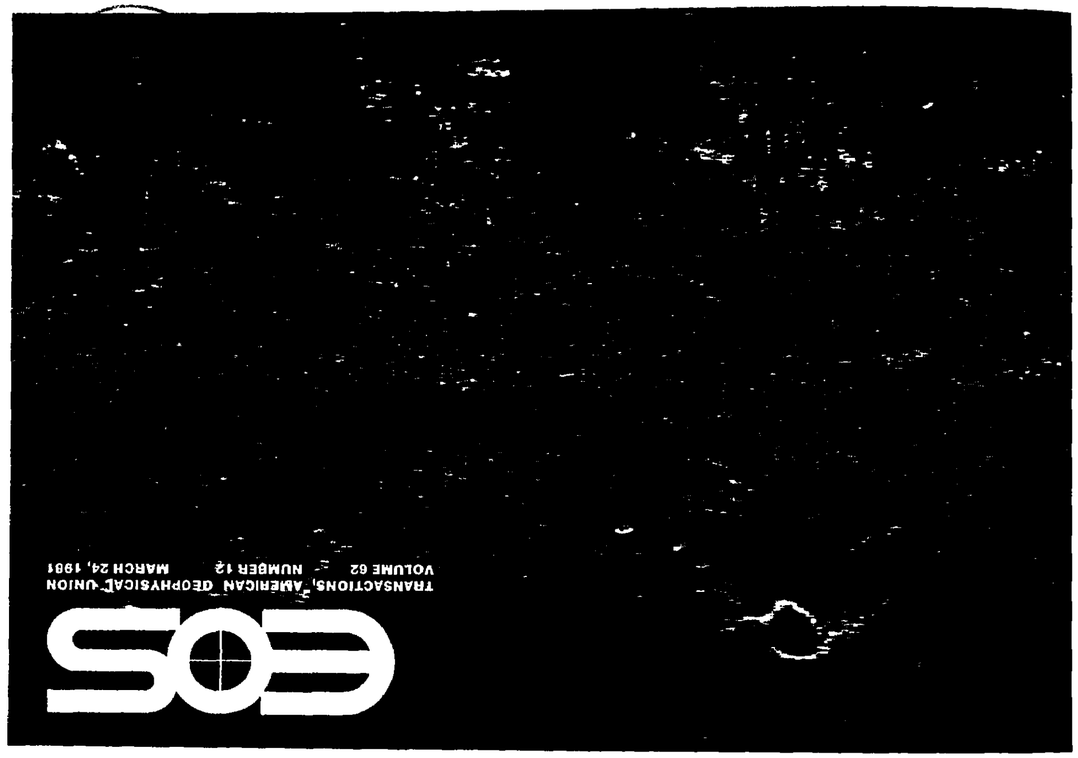

EOS, TRANSACTIONS, AMERICAN GEOPHYSICAL UNION VOL. 62, NO. 12, PAGES 121-128 MARCH 24, 1981

Geodesy and Gravity

1910 Crustal Movements
REPEATED PRECISE GRAVITY MEASUREMENTS ON VANCOUVER ISLAND, BRITISH COLUMBIA
H. Dragert (Pacific Geoscience Centre, Earth Physics Branch, Dept. of Energy, Mines and Resources, P.O. Box 6000, Sidney, B. C. Canada V8L 4B2) A. Lachert and J. Ilard

Over the past three years, repeated precise gravity measurements have been made on Vancouver Island, British Columbia, to test a practical field technique for precise gravimetric surveys and to monitor possible gravity changes associated with contemporary crustal deformation. In order to obtain a precision for measured gravity differences of a few microgals (1 μGal = 10 nms^{-2}), rigorous field survey procedures were followed and the operating characteristics and calibration non-linearities of the LaCoste and Romberg Model D gravimeters were taken into account. Instrument evaluation indicate that although the standard error of the mean of several gravity ties is 3.5 to 2.0 μGal for an individual instrument, the present achievable accuracy of the model D gravimeter for the measurement of temporal gravity changes is 3 to 4 μGal, provided the dial settings of previous surveys are recovered or both long and short wavelength nonlinearities in calibration can be specified. Semi-annual surveys of the central Vancouver Island region indicate significant temporal variations over the past three years. Gravity changes as large as 80 μGal at sites adjacent to lake shorelines are caused by the mass effect of changing water levels and can be accounted for by simple model calculations. A gravity effect of annual changes in groundwater levels is not identifiable in the data, although contaminant network sites are underlain by porous sedimentary subject to seasonal water table fluctuations of 1 or 2 m which are expected to cause gravity variations of the order of 10 μGal. A spatially coherent pattern of long-term gravity trends is indicated in the southern network after corrections have been made for known mass changes. These trends can be interpreted in terms of relative elevation changes of the order of 2 cm/a between Battle Lake and the area to the northeast. Alternatively, a change in density caused by secular changes in water content in the same areas or by compression through an accumulation of stress could also cause the observed gravity trends.
J. Geophys. Res., Red, Paper 180374

1920 Principles of gravity observations in terrestrial and marine
DENSITY DISTRIBUTIONS IN MOHO AND SEDOVIETOLITE, OMAN
M.N. Nafi Toksöz (Massachusetts Institute of Technology, Cambridge, Mass. 02139) and P.G. Cotharp

Four Bouguer and many gravity stations have been established over the Semail ophiolite and adjacent units exposed in the Oman Mountains. The Bouguer anomaly patterns follow more or less parallel to ophiolite exposures. Along the coast of the Gulf of Oman the Bouguer anomaly values range from +20 to +150 mgals and increase northward.

Most gravity profiles across the ophiolite are correlated with known geology and structure. The main gravity profile extending 175 km northward from Ibra to Nakhl and into the Gulf of Oman shows one positive Bouguer anomalies (+85 over the southern folded ophiolite nappe, and +110 mgals near the shoreline at Muscat) that are associated with two nappes of tabular form. The nappes are nearly continuous, and there is no evidence that they are rooted in the centre. The gravity high across the southern nappe is centered over the axis of the synform (maximum nappe thickness); its position over the gabbro-peridotite contact rather than over the peridotite suggests extensive serpentinization of the peridotite. At the southern end of the profile, in the Ibra Bou area, the negative gradient annually (-10 to -15 mgals) is interpreted as an infrasedimentary salt piercement similar to those in the Zagros fold belt. Geologic modelling of the main gravity profile provides a good correlation in terms of 900m thicknesses of the ophiolite units. The nature of the gravity anomaly across the continental margin indicates a transition from 7+2-km thick continental crust to a thinner (5+-1 km) oceanic crust.

The two gravity profiles in the north Oman region show a doublet of positive residual Bouguer anomalies (+50 to +40 mgals). The anomalies correlate well with lubricated ophiolite exposures, a result of low-angle thrusting caused by strong compressive forces. In the absence of lubricate thrusting, the gravity profile in the central region has only one large positive residual Bouguer anomaly (+130 mgals). The anomalies of all the four profiles are further analyzed to elucidate the nappe-transport distances. (Gravity, ophiolite, structure, lithosphere).
J. Geophys. Res., Red, Paper 180127

Geomagnetism and Paleomagnetism

2540 Spatial variations attributed to sea floor spreading
A REVISED MAGNETIC POLARITY TIME SCALE FOR THE PALEOCENE AND EARLY EOCENE AND IMPLICATIONS FOR PACIFIC PLATE MOTION
R. F. Butler and P. J. Coney (Department of Geosciences, University of Arizona, Tucson, AZ 85721)

Magnetostratigraphic studies of a continental sedimentary sequence in the clark's Fork Basin, Wyoming and a marine sedimentary sequence at Gubbio, Italy indicate that the Paleocene-Eocene boundary occurs just stratigraphically above normal polarity zones correlative with magnetic anomaly 25 chron. These data indicate that the older boundary of anomaly 24 chron is 52.5 Ma. This age is younger than the late Paleocene age assigned by LaBrecque et al. [1977] and also younger than the basal Eocene age assigned by Obata et al. [1980]. A revised magnetic polarity time scale for the Paleocene and early Eocene is presented in this paper. Several changes in the relative motion system between the Pacific plate and neighboring plates occurred in the interval between anomaly 24 and anomaly 21. A major change in absolute motion of the Pacific plate is indicated by the bend in the Hawaiian-Emperor Seamount chain at 43 Ma. The revised magnetic polarity time scale indicates that the absolute motion change began the relative motion changes by only ≈3-5 m.y. rather than by 10 m.y. as indicated by previous polarity time scales.
Geophys. Res. Lett., Paper 1L0328

2560 Time variations, paleomagnetism
AN INVESTIGATION OF THE REMANENCE CHARACTERISTICS OF THREE SEDIMENTARY UNITS OF THE SILURIAN MASCARENE GROUP OF NEW BRUNSWICK, CANADA
J.L. Roy (Geomagnetic Laboratory, Division of Geomagnetism, Earth Physics Branch, Ottawa, Ont., Canada K1A 0Y3) P. Anderson

Thermal, chemical, alternating field (AF) and two-stage (AF followed by thermal) experiments were performed on 18 sites (217 specimens) of three sedimentary units (Groups A and B and C) of the Mascarene Group of southeastern New Brunswick. Groups A and B of Pembrokian age (late Late Silurian) apparently carry a dual polarity initial remanence yielding a pole at 087°E,05°S. Group C of probably Ludlow age (older than Pembroke) carries a magnetite remanence and a hematite remanence with the former probably being the initial and yielding a pole at 085°E,28°S. This would indicate a pole shift of some 30° southwards relative to the sampling area during the Upper Silurian, in agreement with the hypothesis that considerable polar shift took place during the Siluro-Devonian period.

The extensive experimental work (over 4,000 treatments) demonstrates the need to use several techniques in the pursuit of the magnetic history of the rock. For example, if the work had been limited to thermal treatment up to 450°C, an overestimate or more likely an apparent remanence could conceivably have been obtained for the initial remanence. Conversely, the considerable information gathered through the use of different techniques allows one to advance and model the most probable scenario of remanence acquisition while contributing additional knowledge about the magnetic characteristics of sedimentary units.

Results from this investigation, including those of a Mascarene Group intrusion also reported here, are discussed in the context of Siluro-Devonian poles of North America. Different options are open to the interpreter assessing the difficulties in establishing both the rock and remanence ages. It is concluded that more data from detailed investigations are needed before the evolution of the eastern seaboard and the Appalachians can be retraced by paleomagnetic means.
J. Geophys. Res., Red, Paper 180410

2599 General or miscellaneous
REMANENT MAGNETIZATION OF ASH FROM THE 18 MAY 1980 ERUPTION OF MOUNT ST. HELENS
William K. Steele (Department of Geology, Eastern Washington University, Cheney, Washington 99004)

Ash from the 18 May 1980 eruption of Mount St. Helens deposited from air faithfully records the direction of the local geomagnetic field in eastern Washington. Where ash settled from suspension in water in fluvial environments exhibits significant inclination and current-lineation errors in magnetic direction similar to those reported in other subaqueously deposited sediments. The current-lineation errors are associated with partial alignment of the major axes of magnetic susceptibility in the direction of water currents. Subaerial deposition produces strong stable remanent magnetization in ash with or without postdepositional wetting by rain. (Remanence, magnetization, volcanic ash; inclination error).
Geophys. Res. Lett., Paper 1L0245

News

Destruction and Recreation of Black Holes

Even though the existence of the gravitationally collapsed concentrations of matter in space known as 'black holes' is accepted at all educational levels in our society, the basis for the black hole concept is really only the result of approximate calculations done over 40 years ago. The concept of the black hole is an esoteric subject, and recently the mathematical and physical frailties of the concept have come to light in an interesting round of theoretical shuffling. The recent activity in theorizing about black holes began about 10 years ago, when Cambridge University mathematican Stephen Hawking calculated that black holes could become unstable by losing mass and thus 'evaporate.' Hawking's results were surprisingly well received, considering the lack of theoretical understanding of the relations between quantum mechanics and relativity. (There is no quantized theory of gravitation, even today.) Nonetheless, his semiclassical calculations implied that the rate of 'evaporation' of a black hole would be slower than the rate of degradation of the universe. In fact, based on these and other calculations, the British regard Hawking as 'the nearest thing we have to a new Einstein' [*New Scientist*, Oct. 9, 1980]. Within the last few months, Frank Tipler, provocative mathematical physicist at the University of Texas, has reexamined Hawking's calculations [*Physical Review Letters, 45*, 941, 1980], concluding, in simple terms, (1) that because of possible vital difficulties in the assumptions, the very concept of black holes could be wrong; (2) that Hawkings' evaporation hypothesis is so efficient that a black hole once created must disappear in less than a second; or (3) that he, Tipler, may be wrong. The latter possibility has been the conclusion of physicist James Bardeen of the University of Washington, who calculated that black hole masses do evaporate but they do so according to Hawking's predicted rate and that Tipler's findings cause only a second-order effect on the rate process [*Physical Review Letters, 46*, 382, 1981].

The concept of a black hole is that as a huge dead star collapses under the acceleration of its own intense gravitational field, and its size is severely reduced, its density or concentration of mass becomes incredibly large. The mass concentration is 'black' because matter cannot escape from its intense gravitational field; even light is held captive. In theory a black hole is thus invisible and undetectable by most means. Any form of energy or matter within range of the intense field will be captured and unable to escape. Although a black hole is an ideal theoretical object, in a sense, because there is no way of observing and therefore of confirming its existence, if it actually exists, its influence on stellar space should be felt, and thus indirect evidence of its existence should be obtainable. For example, as matter is caught within the outer portions of a black hole's gravitational field, the response of that matter to the field and to being swept into the mass of the black hole should be detectable. Astronomers think they have observed high-energy radiation that could have been released by such matter, and the location of several black holes may have been determined. Until the existence of black holes is satisfactorily substantiated, however, they remain, for the most part, subject to theoretical reexamination.

Hawking's calculations seem to have had a positive effect on black hole plausibility. His combination of quantum theory and relativity that resulted in the evaporation hypothesis showed more than ever that black holes should exist, even though a relatively slow process for their eventual destruction was identified. What Hawking concluded was that in the intense surrounding field of a black hole, pairs of matter and antimatter particles would be created. He calculated that one such particle could, at an ever-increasing rate, escape a black hole and leave the influence of its gravitational field entirely. By this process, the black hole would lose mass and energy and eventually not be a black hole anymore. Its size would become too small, and it would release light and self-destruct. The question today is not whether such a process of spontaneous formation of particles and particle loss would occur, but what is the rate and the time scale for the process.

In Frank Tipler's calculations, the process of energy and mass loss of a black hole is so rapid and efficient that a black hole equivalent in mass to the sun would evaporate in less than 1 second. Tipler's efforts in reexamining Hawking's theory are among many in recent years to analyze the approximation of the effective energy-momentum tensor for the process. If the semiclassical quantum effects on the space-time structure of the process are omitted, the result is a mostly classical analysis of a space-time bending, or, as it were, of the very 'space-time warp' that causes formation and evolution of black holes. In playing with the concept, Tipler found that if the effective stress-energy tensor of Hawking radiation ['evaporation'] has negative energy [required by overall conservation of energy] as expected, then an evaporating black hole, initially of one solar mass in size, must disappear in less than a second. He concluded therefore that black holes may not exist at all. He also suggests that predicted quantum effects could preclude the formation of black holes. On the other hand, he concludes that the quantum effects could be sufficiently complex to form black holes and to eliminate their evaporation. All these conclusions would naturally indicate that Hawking was wrong.

Bardeen did not examine the two of Tipler's possible conclusions to the effect that poorly understood quantum effects could prevent black holes from forming or that poorly understood or unknown quantum complexities could eliminate the Hawking evaporation process. What Bardeen did examine was Tipler's main conclusion that the evaporation process, if valid, would result in a rapid instability of the black hole. Bardeen demonstrated mathematically the quasistationary nature of the structure as proposed by Hawking. The result indicates that Tipler's second-order corrections for the evaporation process do not affect the stability in a major way. Thus for the moment, Hawking's calculations, which showed that black holes evaporated in a time longer than the age of the universe, are substantiated, a result that is the 'most exciting development in general-relative-theory during the past decade [which] indicates a deep connection between the apparently disparate disciplines of general relativity, quantum mechanics, and thermodynamics' [*Physical Review Letters, 45*, sup.].—*PMB*

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Cover. Note any similarities between the two photographs? The top photograph was taken in the Dry Valleys of Antarctica (outer flanks of Don Juan Pond, South Fork, Wright Valley, Victorialand, Antarctica (77°34'S, 161°12'E); view toward northeast). Surface rocks have been sculptured by wind action producing ventifacts. The bottom photograph is from the Viking 2 lander site on Mars at Utopia Planitia (48°N, 226°W). The surface rocks have been sculptured by erosional processes. Studies were conducted and samples of soils, rocks, and cores were collected from the Dry Valleys of Antarctica in connection with NASA Mars Data Analysis Program on studies of planetary surface analogs. These analogs may display features of the cold-dry environments associated with both areas. (Photograph and information courtesy of Everett K. Gibson, Jr., NASA, Lyndon B. Johnson Space Center, Houston, Texas.)

Official Earthquake Council Statement

The following is the statement issued by the National Earthquake Prediction Evaluation Council on January 27 (see story above for details).

At the request of the Government of Peru, the director of the U.S. Geological Survey has convened the National Earthquake Prediction Evaluation Council to review the prediction of a major earthquake in Peru. Specifically, the prediction by Drs. Brian Brady and William Spence states that a series of large earthquakes will begin at the end of June 1981, off the coast of Peru.

The sequence is predicted to contain a magnitude 7.5–8.0 event on or about June 28, 1981, a magnitude 8.2 event on or about August 10, 1981, and a magnitude 8.9 event on or about September 16, 1981. The predicted epicenters of these events are all near Lima. We understand that if there is not a substantial increase in the number of earthquakes of magnitude 4.5 or greater in a specific area off the coast of Peru by mid-May 1981, Drs. Brady and Spence will withdraw the prediction.

The members of the council are unconvinced of the scientific validity of the Brady-Spence prediction. The council has been shown nothing in the observed seismicity data, or in the theory insofar as presented, that lends substance to the predicted times, locations, and magnitudes of the earthquakes.

The council regrets that an earthquake prediction based on such speculative and vague evidence has received widespread credence outside the scientific community. We recommend that the prediction not be given serious consideration by the government of Peru.

We cannot say with complete confidence that major earthquakes will not occur at the predicted times, but we judge the probability of this happening to be very low indeed. On the basis of the data and interpretation currently available, none of the members of the council would have serious reservations about being present personally in Lima at the times of the predicted earthquakes.

We are particularly distressed that although this prediction has been publicized in various forms for several years, nothing in the scientific literature or in other written form has been made available to this council on the detailed theoretical basis and methodology of the Peruvian prediction as currently formulated. In fact, the prediction specified in a memorandum by Dr. Brady on May 1, 1980, is quite different from that presented orally at this meeting.

Our rejection of the specific prediction by Drs. Brady and Spence should not be taken as minimizing the risk to lives and property from earthquakes in Peru. Since its founding, Lima has experienced many strong earthquakes, and others must be expected in the future both there and elsewhere along the coastal regions of Peru. Despite the continuing need to prepare for earthquakes in Peru, we do not recommend any special measures in response to the Brady-Spence prediction.

Prediction of Peru Quakes Rejected

In its first evaluation of an earthquake forecast, the U.S. National Earthquake Prediction Evaluation Council denounced the prediction by two geophysicists that a series of major quakes will occur in Peru this summer. Brian Brady of the U.S. Bureau of Mines made the prediction on the basis of a model of rock fracture. William Spence of the U.S. Geological Survey worked with Brady on the investigation of the tectonics near Peru. Despite the council's ruling, Brady maintains his prediction.

Meeting at the request of the Peruvian government, the council evaluated the predictions that seismic activity (magnitude 4.5 or greater) off Peru's coast will increase by mid-May. This increased activity will signal the start of a sequence of three earthquakes: a magnitude 7.5–8.0 event on or about June 28, a magnitude 9.2 event on or about August 10, and a magnitude 9.9 event on or about September 16. Brady and Spence used the Kanamoori scale, which is equivalent to the Richter scale below 8.0 but is more accurate above magnitude 8 because it accounts for low-frequency tremors. The Peruvian government made the request to the U.S. council in response to public apprehension on learning of the forecast.

The major objection raised by the council at its January 26–27 meeting in Golden, Colo., was the lack of documentation on the prediction. 'We are particularly distressed that although this prediction has been publicized in various forms for several years, nothing in the scientific literature or in other written form has been made available to this council on the detailed theoretical basis and methodology of the Peruvian prediction as currently formulated,' according to the official council statement. (See full text of the statement below.)

Brady told *Eos* that he plans to publish a series of manuscripts on his 7 years of work on the model and that he will probably begin publication within the next 6 months, approximately concurrent with the third predicted earthquake.

In addition, the council said it is 'unconvinced of the scientific validity' of the prediction. 'The council has been shown nothing in the observed seismicity data, or in the theory insofar as presented, that lends substance to the predicted times, locations, and magnitudes of the earthquakes.' The council recognized, however, that in the past Lima has been subjected to strong quakes and will probably experience them in the future. But the council told Peruvian officials, 'Despite the continuing need to prepare for earthquakes in Peru, we do not recommend any special measures in response to the Brady-Spence prediction.'

Brady said he will withdraw his prediction if seismic activity does not increase by the end of May or early June, as he expects. Otherwise, he holds fast to his forecast.

'If the first event does occur,' he said, 'there'll be no doubt in my mind about the other two [earthquakes].' However, 'if the first event does not happen, then the probability of the other two is zero or very small.'

Spence's role was to look at the prediction that Brady made and to determine if it was plausible, given the region's tectonics. The large earthquakes are possible, given the tectonics of central Peru and north Chile, Spence told *Eos*. However, 'I think there's a very small chance of the predictions being correct,' he said. 'Even if there's a small chance, however, the risk is extremely great,' he explained. In light of the prediction, 'keeping an eye on the zone' to test the prediction would be 'very prudent,' he added.

'I think scientists should be very careful about issuing predictions, because of the social consequences,' Spence commented. He noted that predictions should be supported with well-documented details.

The council was established in August 1979 to aid the USGS director in issuing formal predictions of earthquakes. Clarence Allen of the California Institute of Technology is chairman and John Filson of the USGS is vice chairman. Other council members participating in the evaluation were E. R. Engdahl, USGS; David Hill, USGS; James Savage, USGS; C. B. Raleigh, USGS; Thomas V. McEvilly, Univer-

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(News cont. from page 129)

sity of California at Berkeley; and Lynn R. Sykes, Columbia University. Members of the council who did not participate are Robert Wallace, USGS; Keiiti Aki, Massachusetts Institute of Technology; T. Neil Davis, University of Alaska; and Neil L. Frank, National Hurricane Center in Florida. James Rice at Brown University, an authority on the physics of rock failure, attended the meeting at the request of the council.—*BTS*

Venus Cloud Studies

Observations of the pattern of atmospheric changes on Venus have been made on the basis of on 2 years of Pioneer orbiter data. The results indicate a long-term period of change for both the planet's wind patterns and for the existence of a haze layer above the cloud tops, according to a recent NASA release. The Pioneer orbiter has taken about 1000 pictures of Venus clouds and extensive measurements of the particles comprising those clouds.

Among the most noteworthy of the results is that Venus' planetwide wind patterns change dramatically over a period of several years. Two patterns have been discerned; a midlatitude jet stream pattern and a cloud and wind pattern that acts like a solid body. It was also observed that the high-altitude haze layer, which completely envelopes Venus' clouds, appears and disappears over several-year periods. This haze is a 'smog layer' extending above the main cloud region by about 30 km. This altitude on Earth would be well into our stratosphere.

The Pioneer Venus orbiter is expected to return pictures and other data until 1985. The orbiter reached Venus in December 1978, and the four Pioneer probe craft entered the atmosphere at the same time. Cloud pictures and polarimetry data are provided by the cloud photopolarimeter.

A multiyear change in the pattern of global winds, and similar changes in the planet-wrapping haze layer, could help explain other features of Venus' atmosphere, such as: Why, on a planet which has almost no axial rotation, do the upper level winds circle the planet at tremendous speeds of 360 km/h. These winds cover the planet completely, blowing at virtually every latitude from equator to pole. Their speeds can be determined from the speeds at which the clouds, carried by the winds, travel around the planet. Wind speed measurements from top to bottom of the atmosphere by the four Pioneer probe craft show that these high-speed, cloud-level winds are coupled to lower-altitude winds, which also have very high speeds.

The 360-km/h cloud level winds blow around the planet at an altitude of 65 km. Wind speeds then range down to 192 km/h at 50-km altitude and to a still very high 80 km/h at 20-km altitude. The mass of the moving atmosphere constituting these high-speed winds is several times that of the entire atmosphere. It represents about a quarter of Venus' atmosphere, which is about 100 times denser than Earth's.

Despite the scale of these high-speed, upper-level winds, well over half of Venus' tremendously dense atmosphere near the planet's surface is almost stagnant. From the surface up to 10-km altitude, wind speeds are only about 3 to 18 km/h. In a general way, the high-speed winds can now be explained as being due to the transfer of momentum from Venus' slow-moving, massive, lower atmosphere to higher altitudes where the atmosphere is less massive, so that the same momentum results in a much higher velocity.

The long-term changes in global wind patterns, and the enormous haze envelope which appears and disappears, could be responsible for the planet's high-speed winds. Any future general atmosphere circulation model for Venus will have to produce these long-term changes in wind and cloud patterns.

Set out below are details of the major findings from the 2-year analysis of the Venus cloud and polarimetry data.

- It is now clear that the high-speed movements of Venus' clouds around the planet are not caused by wave motions in the atmosphere, as was previously thought, but are real winds, though there are some wave motions as well. These planet-circling winds, which carry along the clouds, are the same ones that were measured by the four Pioneer Venus probe craft as they descended to Venus' surface in December 1978. These winds blow in an east to west direction, circling the planet once every 4 days at speeds near the equator of 360 km/h and near the poles (at around 70° latitude) of 160 km/h. The Pioneer cloud pictures show the region of Venus' main cloud deck at altitudes between 60 and 65 km above the planet's surface.
- The global pattern of these planet-circling, cloud-level winds appears to change periodically. For the past 2 years of Pioneer observations, Venus' clouds and cloud-level winds have been evidencing 'solid body' rotation. That is, they move around Venus as though they were made up of one solid planet-encasing body. This pattern of motion, of course, means wind speeds are much higher at the equator than at the poles.
- In 1974, when the Mariner spacecraft flew past Venus, the clouds did not circle the planet as a solid body, and there were mid-latitude jet streams at around 45° latitude. These higher-speed winds had velocities of around 400 km/h, while wind velocities at the equator were some 40 km/h lower, at 360 km/h. This seems to indicate that there is an irregular cycle of change in the pattern of these cloud-level winds—perhaps several years in length. The duration and rate of change of this cycle of changing wind patterns would be of fundamental interest in understanding the high-speed flow of Venus' upper-level winds around the planet, as well as the behavior of the general atmosphere circulation.
- Measurements of Venus' cloud level winds show that, in addition to circling the planet, they also blow toward the poles at speeds of around 25 km/h. These equator-to-pole winds (also seen by the four Pioneer probes at lower altitudes) carry heat, absorbed near the Venus equator, from the sun to the poles.

The observed speeds of equator-to-pole winds agree with the wind measurements by the four Pioneer probes. According to the NASA report, this indicates that the cloud-level winds are the upper limb of an equator-to-pole Hadley cell circulation loop that carries Venus' equatorial heat poleward.

- The so-called global 'Y' pattern of Venus clouds, with the tail of the 'Y' extending eastward around the planet and the arms westward, appears at times, but is not typical. The 'Y' was first seen in ground observations. Sometimes the 'Y,' which occasionally extends two thirds of the way around the planet, disappears completely. At other times, it is so changed that it forms a 'C' or other shape. In general, the planet shows a whole range of global cloud patterns in addition to the 'Y.'
- In addition to its well-known veil of clouds, 2 years of Pioneer polarimetry measurements show that Venus is currently enveloped in an 18-mile-thick blanket of high-altitude haze. The haze is present everywhere, but has about 3 times more particles per unit volume at the poles than at the equator. At the poles the haze is so thick that it obscures the base clouds beneath it. This haze of tiny sulfuric acid droplets is the 'sealer' of Venus' greenhouse effect, holding additional heat beyond that which would be trapped by the clouds and atmosphere alone. The planet's 484° C surface temperature would be somewhat lower without the haze. Furthermore, inclusion of haze effects makes the Venus heat radiation models developed by scientists match the cloud top atmosphere structure observed by the Pioneer Venus instruments.

Venus' main clouds consist of sulfuric acid particles 2 microns in diameter, while in the haze layer the particles are smaller—only a quarter of this size.—*PMB*

Satellites Pinpoint Tornado Clouds

Research into ways to integrate data from satellites and other sources is helping weather forecasters improve their ability to determine quickly where thunderstorm clouds, and perhaps tornados, may occur. Field offices of the National Earth Satellite Service are using new technology to help Weather Service forecasters determine within hours when conditions are right for potentially dangerous storms. J. Purdom, a meteorologist with the satellite service's applications laboratory, is attempting to create methods to help forecasters use satellite imagery to understand why thunderstorms develop as they do. Although the evolution of a thunderstorm often appears random when viewed by radar, satellite data may allow forecasters to predict certain behavior accurately.

Under the right circumstances according to Purdom, a thunderstorm in one location, even after it has dissipated, can affect conditions miles away. It can even be instrumental in creating new thunderstorms, which often spawn severe weather.

'The satellite is the finest small-scale weather observing system we have. Visible sensors on the satellite allow us to observe clouds as small as one-half mile in size during daytime, while infrared sensors provide observations both day and night with a resolution of 4 miles.

'Clouds and cloud patterns in a satellite image represent the integrated effect of ongoing dynamic and thermodynamic processes in the atmosphere,' he explained. 'When that information is combined with more conventional data such as radar, the interactions in the atmosphere that are so vital in the formation and continuance of thunderstorm activity can be better understood.'

Purdom said repetitive situations occur frequently. Thunderstorm-induced phenomena later trigger thunderstorm systems miles away, giving rise to tornadoes and severe weather. The phenomena often can be recognized through animated satellite imagery. Consequently, the creation of new thunderstorms, as well as their proximity to the influencing storms, can be predicted—hopefully.

Purdom said this knowledge allows severe storm forecasters to concentrate on particular cloud formations during the tornado season. 'Meteorologists seeing the series of events are alerted to pay special attention to the areas where thunderstorm development will occur during the next few hours, thus helping them better isolate the severe storm areas and watch them more carefully with radar,' he concluded.—*PMB*

OSTP Gets Acting Director

Amid rumors that the Office of Science and Technology Policy (OSTP) will be abolished, President Reagan appointed Benjamin Huberman as acting director, effective March 5.

Although the size and shape of the science policy office and the influence it will have under the Reagan administration are undetermined, rumors that the office will be abolished should be discounted, an OSTP official said. The search for a full-time, permanent director is underway, according to a White House official. He added that the new administration seems to be looking for someone from industry.

Huberman, the acting director, served jointly as associate director of OSTP and as a staff member of the National Security Council since 1977. For the 2 years before that, he was director of the Office of Policy Evaluation at the Nuclear Regulatory Commission.—*BTS*

Geophysicists

James F. Devine has been appointed assistant director for engineering geology at the U.S. Geological Survey National Center in Reston, Va. He succeeds *Henry Coulter*, who recently retired. As part of his new job, Devine will administer the oil and gas exploration program on Alaska's North Slope.

Edward C. Stone, project scientist for NASA's Voyager mission, was presented with the 1981 American Education Award by the National School Supply & Equipment Association.

The following geophysicists were elected as Fellows of the American Association for the Advancement of Science at the January AAAS meeting in Toronto:

Kinsey A. Anderson, Eugene W. Bierly, Joost A. Businger, John V. Byrne, James E. Case, Ralph J. Cicerone, C. Sharp Cook, Joe S. Creager, Alexander J. Dessler, Parke A. Dickey, Thomas M. Donahue, Farouk El-Baz, Cesare Emiliani, Richard S. Fiske, W. Lawrence Gates, Yacov Y. Haimes, Pembroke J. Hart, Robert A. Helliwell, Richard H. Jahns, Paul C. Jennings, Harold S. Johnston, W. Barclay Kamb, William H. Kanes, Carl Kisslinger, LaVerne D. Kulm, Keith A. Kvenvolden, Louis John Lanzerotti, Jon C. Liebman, Julius London, William A. Nierenberg, Stanton J. Peale, Dallas L. Peck, James R. Rice, Kevin S. Rodolfo, Christopher T. Russell, Samuel M. Savin, Robert Blackburn Scott, III, Leon T. Silver, Lynn R. Sykes, Jan Thiede, Henry George Thode, George R. Tilton, M. Nafi Toksoz, Selya Uyeda, Tjeerd H. van Andel, Warren M. Washington.

New Publications

Concepts in Geodetic Reference Frames

Helmut Moritz, *Rep, 294*, The Ohio State University, Columbus, Ohio, iv + 58 pp., 1979.

Reviewed by E. M. Gaposchkin

Reference frames have long been the province of physics and geodesy. Geophysics has not been interested and with some justification. The principal concern in observing the earth has been to refer observations suitably to something. The geophysical fluid dynamicist reduces his data to isobaric surfaces, and the tectonophysicist is interested only in relative changes, etc.

With the inexorable increase in accuracy of metric observations it is now possible, for example with space techniques, to measure with centimeter accuracy the ocean surface, displacements of the solid earth on continental scales, and the motion of our deformable planet in space. It therefore becomes incumbent on us to understand fully the reference systems employed with these measurements if we are to study variations of the earth and not the variations in a reference system we have ourselves invented. This philosophical concern, which finally came to be known as general relativity or geometrodynamics, was thoroughly discussed in the first decades of this century. Now geodesists and geophysicists are beginning to explore, debate, and adopt reference systems, and this specialized topic is receiving increasing attention by theorists and those working with data. It is particularly appropriate to have a general review of geodetic reference frames at this time.

The author has provided a good review and a starting point for discussion with this report, which is written with clarity and is highly informative. It is an orderly treatment in nine chapters and is complete but not a synthesis or treatise. Writing from a particular point of view, that of a geodesist and educator, Moritz casts the development in familiar geodetic terms: network, datum, origins, etc. As a geodesist he is comfortable with using a least squares minimization condition to define a coordinate system. As an educator, Moritz has developed the ideas proceeding from the simple to the complicated, leaving out details at times for ease of development, eliciting from the reader the next step. It is therefore quite uneven. Some topics are discussed several times (i.e., the motion of the earth's pole and the conventional international origin are discussed in four of the chapters).

The aim of this report was as a review, and a great deal of classical geodetic formulation is given. In the chapter on relativistic aspects, however, Moritz has broadened the scope and has given some interesting results, both in terms of general relativity as seen by a geodesist and of the philosophical basis for establishing absolute or preferred reference frames. Moritz's interpretation of the principle of general covariance is unconventional. However, he does develop the idea of using the tidal forces of general relativity to separate gravitational and inertial forces, which seems at first a contradiction of the principle of equivalence.

This report touches most of the issues in establishing a terrestrial reference frame. Moritz does not advocate particular solutions but has provided food for thought.

E. M. Gaposchkin is with the Smithsonian Astrophysics Laboratory, Cambridge, Massachusetts.

New Listings

Items listed in New Publications can be ordered directly from the publisher; they are not available through AGU.

Applications of Marine Geodesy in Support of National Objectives in Ocean Science, Engineering and Operations, N. Saxena (Ed.), University of Hawaii College of Engineering, Manoa, Hawaii, 1980.

The Geology of Europe, D. V. Ager, John Wiley, New York, xix + 535 pp., 1980, $44.95.

Proceedings of the International Workshop on Atmospheric Water Vapor, A. Deepak, T. D. Wilkerson, L. H. Ruhnke (Eds.), Academic, New York, xvi + 695 pp. 1980, $45.00.

Real-Time Forecasting/Control of Water Resource Systems, E. F. Wood (Ed.), Pergamon, New York, ix + 330 pp., 1980, $58.00.

Scientific Basis for Nuclear Waste Management, vol. 2, C. J. M. Northrup, Jr., (Ed.), Plenum, New York, xix + 936 pp., 1980, $65.00.

The Scientific Ideas of G. K. Gilbert: An Assessment on the Occasion of the Centennial of the United States Geological Survey (1879–1979), Special Paper 183, E. L. Yochelson (Ed.), Geological Society of America, Boulder, Colo., vii + 148 pp., 1980, $17.00.

Seafloor Spreading Centers, P. A. Rona and R. P. Lowell (Eds.), Dowden, Hutchinson & Ross, Inc., Stroudsburg, Pa., xv + 424 pp., 1980, $45.00.

Search Theory and Applications, K. B. Haley and L. D. Stone (Eds.), Plenum, New York, ix + 277 pp., 1980.

Solar and Interplanetary Dynamics, M. Dryer and E. Tandberger-Hanssen (Eds.), D. Reidel, Boston, Mass., xix + 558 pp., 1980, $55.00.

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Postdoctoral Position/Planetary Physics. A research associate position is available for the study of Jovian planet interiors under Jupiter Data Analysis Program. Areas of interest include high-pressure equations of state and calculation of structure of rotating planets to high accuracy. Position open until filled. Please send resume and names of three references to:

W. B. Hubbard
Department of Planetary Sciences LPL
323 Kuiper Space Sciences Bldg.
University of Arizona
Tucson, AZ 85721

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Geologist/Environmental Scientist. To teach geology and related physical & earth sciences; emphasis in undergraduate geosciences, sedimentary geology, environmental sciences. Published research, experience in data processing and marine science desired. Ph.D. preferred for tenure track position.

Please send resume plus names, addresses & phone numbers of 3 references by April 23, 1981 to Dr. Alvin F. Shaw, Dean, School of Science, William Paterson College, Drawer TT, Wayne, NJ 07470.

Faculty Position in Oceanography Geology/ University of Northern Colorado. The Department of Earth Sciences invites applications for a tenure-track faculty position in oceanography, starting September 1981. We are seeking a person with a broad background in oceanography and one or more of the related earth science fields such as marine geology and/or sedimentology. Major responsibility will be teaching beginning and advanced courses in oceanography, courses in the related field, and general education courses. A modest amount of research is possible and is encouraged. Applicants should possess the Ph.D. degree or be in the final stages of completion of that degree. Starting rank and salary will depend on experience and other qualifications of the candidate selected.

Applicants should submit a resume and at least three letters of recommendation to Dr. L. Glen Cobb, Chairman, Department of Earth Sciences, University of Northern Colorado, Greeley, CO 80639.

The deadline for application is May 10.

Sedimentary Geologist/Micropaleontologist, Washington University. The Department of Earth and Planetary Sciences, Washington University, has available a tenure track, assistant professorship position, beginning in the 1981–82 academic year for a geoscientist with research interests in diagenesis of sediments or in micropaleontology.

The successful candidate must have the following attributes: demonstrated creativity and promise of excellence in research and teaching; intent to develop a vigorous graduate research program; desire to teach courses in field of interest and related fields of geoscience at undergraduate and graduate levels.

Send resume, statement of future research interests, and names of at least three references, to Larry Haskin, Chairman, Department of Earth & Planetary Sciences, Washington University, St. Louis, MO 63130. Applications received through April 15, 1981.

Washington University is an equal opportunity/affirmative action employer.

Texas Tech University: Faculty Positions. The Department of Geosciences is seeking applications for additional faculty members in geology, geophysics and geochemistry; applicants from all fields of geology other than paleontology will be given serious consideration.

These are tenure track positions at the assistant professor level with appointments starting September 1, 1981.

Applicants must have completed their doctoral programs, be interested in teaching at both the undergraduate and graduate levels, and have specific plans for research in their fields of specialization.

Applicants for the positions should submit resumes, the names of at least three persons from whom the department may request letters of recommendation, and brief description of research interest to:

Donald R. Haragan, Chairman
Department of Geosciences
Texas Tech University
P.O. Box 4109
Lubbock, Texas 79409

Texas Tech University is an equal opportunity/affirmative action employer.

Structural Geologist. The Department of Geophysical Sciences invites applicants for a tenure track structural geology position at the assistant or associate professor level, beginning August 1981. Ph.D. required. Salary commensurate with experience and qualifications.

Departmental equipment includes a digitizer, various geophysics equipment, and a remote sensing laboratory with an edgewise enhancer. The candidate will have the opportunity to substantially add to his or her equipment needs. Present computer facilities include a DEC 10 and IBM 360-44, while PK 3240 system with 16 megabyte capacity is under development.

ODU is a state-supported university serving nearly 15,000 students and is situated within the seventy Hampton Roads metropolitan area that is nationally known for its historic, recreational, and cultural facilities.

Send vitae, a brief discussion of research interest, and arrange to have three letters of reference by May 1, 1981 to Dr. Dennis A. Darby, Chairman, Department of Geophysical Sciences, Old Dominion University, Norfolk, VA 23508.

An affirmative action/equal opportunity employer.

Harvard University/Postdoctoral Research Fellowship. Harvard University will offer a postdoctoral research fellowship in some field of experimental geology or geophysics for the academic year(s) 1981–1982 and/or 1982–1983. Stipend will be $17,000 for one year with possibility of renewal for a second year. Interested applicants should send a resume, a statement of proposed research, and arrange for at least two letters of reference to be sent to the Chairman, Committee on Experimental Geology and Geophysics, Harvard University, Cambridge, MA 01238. Deadline is June 1, 1981 for applicants desiring appointment in 1981–1982; December 1, 1981 for applicants desiring appointment in 1982–1983.

Harvard University is an equal opportunity/affirmative action employer.

Postdoctoral/Research Associate Positions, The Johns Hopkins University, Applied Physics Laboratory. Positions are available for studies of magnetospheric-ionospheric coupling hydromagnetic waves, and plasma instabilities in the ionosphere and magnetosphere. The selected candidates will participate in the analyses and interpretation of data from spacecraft and ground-based radars as well as in the development and implementation of new ground-based and spacecraft studies. Positions are for one year and are renewable. Tenure may begin at any time through September 1, 1981. Applications should be addressed to Mr. Steven F. Sayre, Dept. ADI-15, The Johns Hopkins University, Applied Physics Laboratory, Johns Hopkins Road, Laurel, MD 20820.

An equal opportunity employer, m f.

Seismologist. The Department of Geology at the University of Illinois, Urbana-Champaign, has an opening for a tenure track position at the assistant professor level, beginning during the 1981–82 academic year. A Ph.D. is required. The applicant should have a strong background in geology, and post-doctorate experience is desirable. Candidates with interests and experience in tectonic studies based on seismological observations will be given preference. The successful candidate is expected to develop an active research program to complement existing programs in geodynamics, solid earth geophysics, and rock physics. There is also opportunity for interaction with programs in the Departments of Theoretical & Applied Mechanics and Civil Engineering, and the Interdisciplinary Materials Research Laboratory. Send resumé and names of three references to: Dr. John Hower, Head, Department of Geology, University of Illinois, 245 Natural History Bldg., 1301 W. Green St., Urbana, IL 61801 (Telephone: 217/333-3542). Applications should be received by April 15, 1981.

The University of Illinois is an affirmative action/equal opportunity employer.

Princeton University/Scientific Programmers and Data Analysts. The Geophysical Fluid Dynamics Program of Princeton University seeks applicants for two full time scientific programming positions that may become available in July 1981. These programmers will become part of a research group that is making use of measurements of a variety of chemicals in the world oceans to learn about oceanic circulation and mixing. One position involves data analysis and the other involves developing computer simulations.

Applicants should have a bachelor's or master's degree in oceanography, physics, chemistry or engineering with a strong math background. Fortran programming and course work in oceanography are required.

Salary is $15,000 to $17,000 per year.

Send a resume, course transcript and names of 3 references to Prof. Jorge L. Sarmiento, Director, Geophysical Fluid Dynamics Program, Princeton University, Princeton, NJ 08544.

Princeton University is an equal opportunity/affirmative action employer M/F.

Director Meteorology Division, Air Force Geophysics Laboratory. Air Force Geophysics Laboratory invites applications for the position of Director of the Meteorology Division located at Hanscom Air Force Base, Massachusetts. The Division is responsible for Air Force research and development in meteorology, atmospheric physics, remote and direct sensing technology, climatology, and relative technologies. The division director provides overall direction to an R&D program which employs over 80 people and covers a broad range of in-house and contractual scientific investigation. A candidate should have a record of distinguished achievement in meteorology/atmospheric physics as a research scientist and manager of a substantial R&D unit. This position is Air Force Senior Executive Service with a salary range of $52,247 to $57,673, subject to current $50,112 ceiling. For an application package, call collect: Robert Eberly, (617) 861-2896. To be considered, applications must be returned by 30 April 1981.

Equal employment opportunity employer.

Ph.D. Scientist/Chemistry and Aeronomy. The National Center for Atmospheric Research in Boulder, Colorado is seeking an individual for an initial 3-year appointment to undertake numerical modeling experiments and theoretical studies in atmospheric photochemical processes. Requires: Ph.D. in chemistry, physics or atmospheric sciences or equivalent, applicable research experience and high level skills in the following: numerical modeling and theoretical studies of atmospheric photochemistry, numerical solution of differential equations and programming of an advanced computer in FORTRAN.

Send resume including publications list and 5 names of references to Margareta Domecki, NCAR, P.O. Box 3000, Boulder, CO 80307.

NCAR is an Equal Opportunity/Affirmative Action Employer.

Geophysicist. Applications invited for a tenure track position at the assistant or associate professor level, beginning August 1981. Successful candidate will be expected to develop graduate courses in area of expertise and to teach undergraduate geophysics. Although all areas of geophysics will be considered, preference will be given to professionals with teaching and research interests in seismic stratigraphy and petroleum exploration.

Departmental equipment includes a refraction seismograph, resistivity meter, gravimeter, magnetometer, perometer, and permameter. The candidate will have the opportunity to substantially add to his or her equipment needs.

Present computer facilities include a DEC 10 and an IBM 360-44, while a PK 3240 system with 16 megabytes capacity is under development.

ODU is a state-supported university serving nearly 15,000 students and is situated within the seventy Hampton Roads metropolitan area that is nationally known for its historic, recreational, and cultural facilities.

Salary commensurate with experience and qualifications. Send vitae, a brief discussion of research interest, and arrange to have three letters of reference by April 10, 1981 to Dennis A. Darby, Chairman, Department of Geophysical Sciences, Old Dominion University, Norfolk, VA 23508.

An affirmative action/equal opportunity employer.

Stanford University and San Jose State University: Atmospheric Sciences/Research Associate. Applications are invited for a position as research associate which will be available in June 1981. This position involves development of a three dimensional numerical planetary boundary layer model of the fate of large point source plumes in a coastal urban environment. Interested candidates with modeling experience and possessing the Ph.D. in atmospheric science, meteorology, or related areas are invited to submit a curriculum vitae and references to: Prof. Robert Street, Department of Civil Engineering, Stanford University, Stanford, CA 94305 or Prof. Robert Bornstein, Department of Meteorology, San Jose State University, San Jose, CA 95192.

Both universities are equal opportunity/affirmative action employers.

Professor/Oceanography. The Department of Oceanography of Texas A&M University invites applications for an academic faculty position. The appointment is expected to be made at the level of professor in one of the major sections of the Department—biological oceanography, chemical oceanography, geological and geophysical oceanography, or physical oceanography.

Hence, applications are solicited from individuals who have demonstrated scholarship in research and teaching in any oceanographic subdiscipline. Outstanding applicants suitable for appointment to academic ranks other than professor will also be considered, but preference will be given to applicants suitable for appointment to the higher ranks.

To apply, or for further information, please contact Professor R. O. Reid, Head, Department of Oceanography, College Station, TX 77843 (713/845-7211).

Texas A&M University is an affirmative action/equal opportunity employer.

Stratigrapher, Leave of Absence Replacement. Applicants are invited to fill a position in stratigraphy-sedimentology beginning September 1, 1981. Ph.D. is preferred. We require an enthusiastic teacher to provide instruction in the above areas as well as historical and petroleum geology, with an interest of stimulating undergraduate research. This is a small department which emphasizes field studies and close work with students. Send resume, transcripts and reference letters to James F. Olmsted, Chairman, Department of Earth Sciences, Box 200, S.U.N.Y., Plattsburgh, NY 12901.

An EO/AA employer.

HEAD INFORMATION OFFICE

The National Center for Atmospheric Research in Boulder, Colorado has a position available immediately for a highly skilled person to manage the NCAR information office, whose responsibilities include receiving over 25,000 visitors annually at the NCAR laboratory, handling and initiating contacts with local and national media, and writing and distributing news releases and other informative material designed to generate national and local coverage of NCAR activities, goals, and achievements.

Necessary qualifications include demonstrated skill in science writing for lay and semi-technical readers, in dealing with representatives of national media and in managing a multi-faceted information function in a scientific setting. Please send letter and resume promptly to Dr. G. W. Curtis, P.O. Box 3000, Boulder, Colorado 80307.

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

An equal opportunity/affirmative action employer.

NCAR

South Dakota School of Mines & Technology. The Department of Geology and Geological Engineering anticipates two tenure track positions in economic geology beginning fall 1981. (1) Crystal chemistry/mineralogy/petrology of igneous and metamorphic rocks with emphasis on mineral deposits. (2) Geology of strata-bound or hydro-thermal deposits. Number one is at the full professor level, number two at the assistant or associate professor level. Please send resume and three letters of reference to Alvis Lisenbee, Department of Geology and Geological Engineering, South Dakota School of Mines & Technology, Rapid City, SD 57701 (605-394-2461).

South Dakota School of Mines is an equal opportunity/affirmative action employer.

Purdue University. A tenure track appointment in the area of surveying and mapping. Undergraduate teaching in the areas of basic surveying, adjustment computations, and introductory photogrammetry/photo interpretation; involvement in teaching graduate level courses, and in existing and new research programs.

Preferential consideration to candidates with a Ph.D. and land surveying registration (or in the process of getting such degree and registration); rank and salary are open and depend on the experience and qualifications of the applicant.

Send resumes, by 15 April 1981, to Head, School of Civil Engineering, Purdue University, West Lafayette, IN 47907.

Purdue is an equal opportunity/affirmative action employer.

Postdoctoral Position/Earth and Space Sciences Institute, Tucson. To assist in analysis and interpretation of data from the Voyager Ultraviolet Spectrometer. Possible fields of research include the bound and extended atmospheres of Jupiter, Saturn, and Titan. Applicants should have a Ph.D. and expertise in several of the following areas: atmospheric physics, plasma physics, atmosphere-magnetosphere interactions, computer programming and simulation, and UV spectroscopy in the laboratory or space. Applicant should send resume, list of publications, and names of three references to Bill R. Sandel, Earth and Space Sciences Institute, University of Southern California, 3825 East Ajo Way, Tucson, AZ 85713.

USC is an equal opportunity/affirmative action employer.

Faculty Position: University of Iowa. The Department of Physics and Astronomy anticipates one or two openings for tenure track faculty in August 1981. Research specialties for which substantial resources are available are magnetospheric and auroral physics and space and laboratory plasma physics, both theoretical and experimental. Other specialities of interest are astronomy, astrophysics, elementary particle physics, atomic physics, condensed matter, and low energy nuclear physics. The position involves undergraduate and graduate teaching, guidance of research students, and personal research. Interested persons should send a résumé, a statement of research interests, and the names of three professional references to Search Committee, Department of Physics and Astronomy, University of Iowa, Iowa City, IA 52242.

The University of Iowa is an equal opportunity/affirmative action employer.

Professor/Chemical Oceanography. The Department of Oceanography of Texas A&M University invites applications for an academic faculty position. The appointment is expected to be made at the level of professor.

Hence, applications are solicited from individuals who have demonstrated scholarship in research and teaching. Outstanding applicants suitable for appointment to academic ranks other than professor will also be considered, but preference will be given to applicants suitable for appointment to the higher ranks.

To apply, or for further information, please contact Professor R. O. Reid, Head, Department of Oceanography, College Station, TX 77843 (713/845-7211).

Texas A&M University is an affirmative action/equal opportunity employer.

Petrology/Geochemistry, University of New Brunswick. The Department of Geology has a tenure track position available from 1 July, 1981, at assistant professor or higher level. The successful applicant will be expected to teach both undergraduates and graduates as well as carrying out research and supervising graduate students. This position is in addition to one currently advertised for a rock mechanic or geochemist.

The applicant should have a background in petrochemistry and petrology and should be prepared to teach in some aspects of petrology and geochemistry. The successful applicant will be responsible for supervision of analytical facilities including an X.R.F.

Applicants should have a Ph.D. and preferably, post doctoral experience. Applications including a curriculum vitae and names of three referees should be sent to P. F. Williams, Chairman, Department of Geology, University of New Brunswick, Fredericton, N.B. E3B 5A3.

Exploration Geophysicist/University of Oklahoma. The School of Geology and Geophysics at the University of Oklahoma will hire an experienced exploration geophysicist to fill the Frank and Betty Schultz Professorship, and is seeking nominations and applications for the position. The person must be a distinguished scientist who has made important contributions to exploration geophysics through research. Preference will be given to a scientist whose specialty is seismic properties of earth materials and who has earned the Ph.D. The Schultz Professor will provide leadership and guidance in establishing a quality teaching and research exploration geophysics group. The University of Oklahoma has recently made a strong commitment to the earth sciences with the establishment of a College of Geosciences, to be housed in a new building. The School of Geology and Geophysics will expand from its present faculty of 16 to 26 faculty members by 1986. This will include three scientists in the exploration geophysics area, five in structure-tectonophysics-solid earth geophysics and others in stratigraphy-paleontology, geochemistry-petrology, and energy resources.

Applications are due April 30, 1981. Inquiries, nominations, and applications should be sent to John Wickham, Director, School of Geology and Geophysics, University of Oklahoma, Norman, OK 73019.

The University of Oklahoma is an equal opportunity employer.

Faculty Appointment/Colorado State University. The Department of Earth Resources, Colorado State University invites applications for a tenure track appointment with emphasis on active research experience in remote sensing, and an interest in teaching graduate and undergraduate students beginning September 1981. The candidate is expected to have a Ph.D. degree in geology, watershed sciences or in a related field and is expected to develop and maintain a vigorous research program with special emphasis on the application of state-of-the-art remote sensing techniques to the investigation of natural resource phenomena. The candidate is expected to teach undergraduate and graduate courses in the application of remote sensing to natural resources.

Rank and salary are open and dependent on experience and qualifications of the applicant.

Applicants are invited to submit curriculum vitae, three letters of reference and a letter describing research and teaching interests to Dr. H. S. Boyne, Department of Earth Resources, Colorado State University, Fort Collins, Colorado 80523/(303) 491-5298.

Deadline for receipt of applications is April 15, 1981.

CSU is an EOE/AA. E.O. Office: 314 Student Serv. Bldg.

Seismologist: University of Utah. The University of Utah is expanding its geophysics program in the Department of Geology and Geophysics by adding a tenure track faculty member in seismology at the assistant to associate professor level. Applicants with backgrounds and specialties in seismic imaging and theoretical seismology will be given preference. The individual will be expected to teach undergraduate and graduate courses, and to pursue an active research program with graduate students.

The department has modern teaching and research programs in geology and geophysics, and has close associations with the numerical analysis and data processing groups in computer science, electrical engineering, and mathematics. The geophysics component of the department has strong research and teaching programs in electrical and electromagnetic methods, thermal properties of the earth, potential fields, and seismology. Current research in seismology includes: earthquake research utilizing a new PDP 11/70 computer; monitoring of the Intermountain seismic belt by a 55 station telemetered network utilizing a new on-line PDP 11/34 computer; major experiments in seismic refraction and reflection profiling for crustal structure, and allied research in tectonophysics of mountain building.

The closing date for applications is May 1, 1981 and the appointment date is September 1981. However, the search may be extended if a suitable candidate is not selected, in which case applicants for a one-year visiting position for the academic year 1981–82 will also be considered.

A Ph.D. is required for this position.

Applicants should submit a vita, transcripts, a letter describing his/her research and teaching goals, and names of five persons for reference. Qualified persons should send their applications to William P. Nash, Chairman, Department of Geology and Geophysics, University of Utah, Salt Lake City, Utah 84112.

University of Utah is an equal opportunity/affirmative action employer.

Head: Earth Resources Branch, NASA/ Goddard Space Flight Center. GS-1330-14/15: $37,871–$50,112 per annum, full-time permanent. The Earth Survey Applications Division, Applications Directorate, NASA/Goddard Space Flight Center invites applications for the open position of Head, Earth Resources Branch. The incumbent of this position is responsible for planning, managing, and conducting broad programs in earth resources remote sensing basic and applied research and data analysis, emphasizing the development and demonstration of applications of remote sensing of earth resources from earth orbiting satellites. The primary areas of research in the Branch are land use management, vegetation sciences including agriculture/forestry/rangeland and environmental monitoring utilizing remotely sensed data and advanced technologies. Also, significant effort is dedicated to sensor data evaluation in terms of applications and scientific utility, and to specification of data acquisition and information extraction systems which best meet user scientific and resource management needs. An advanced degree in earth or physical sciences is required with education in the vegetation sciences, land use or environmental monitoring being specifically preferred. Candidates should also have several years of progressively more responsible experience in the conduct, guidance and management of remote sensing research programs and clear evidence of a strong research background indicating senior research scientist status.

Resumes/SF 171's should be sent to:

Dr. Robert D. Price, Assistant Chief
Earth Survey Applications Division
Code 920
Goddard Space Flight Center
Greenbelt, MD 20771

Deadline for applications is April 30, 1981.

Ground-water Geophysicist

Woodward-Clyde Consultants, a geosciences and engineering consulting firm, has an immediate opening in its Orange, California office for a ground-water geophysicist. This position will be in association with a 26-person interdisciplinary Water Resources Section headquartered in San Francisco.

Responsibilities

The successful candidate will participate in geophysical aspects of hydrogeological studies, business development, peer and project review, and project management.

Requirements

A minimum of a MS plus 2-3 years experience, -or- PhD, in both theoretical and applied aspects of groundwater geophysics. Project management and business development experience preferred.

Send resume with references by April 30, 1981 to:

David A. Stephenson, Chief
Water Resources Section

Woodward-Clyde Consultants

Three Embarcadero Center, Suite 700
San Francisco, California 94111

We are an Equal Opportunity Employer

Planetary Geologist. Tenure track assistant to associate professor position starting September 1, 1981, or as soon as possible thereafter to teach and conduct research in planetary geologic processes on Earth and other planets. Research should be on understanding the physical processes (for example, impact cratering, volcanism, tectonism) responsible for the origin of planetary surfaces. Applicants must have Ph.D. in planetology, geophysics or geology. Deadline for applications is June 15, 1981. Inquiries to: Paul C. Hess, Chairman, Department of Geological Sciences, Brown University, Providence, RI 02912.

An equal opportunity and affirmative action employer.

Structural Geologist. The Department of Geosciences of Purdue University invites application for a tenure track faculty position in structural geology, starting in August 1981. Rank and salary will be commensurate with qualifications. A Ph.D. is required. The individual will be expected to teach undergraduate and graduate courses in structural geology and tectonics, participate in summer field courses, and pursue an active research program. Preference will be given to a candidate with an applied field orientation and a strong background in the quantitative analysis of field data. The department has active programs in petrology, geophysics, and engineering geology and has a close working relationship with the geotechnical group in civil engineering and the Laboratory for Applications of Remote Sensing. Closing date for application is April 1, 1981. Applicants should send a resume, the names, addresses, and telephone numbers of three referees, and a brief statement of research interests to R. H. McCallister, Department of Geosciences, Purdue University, West Lafayette, IN 47907.

Purdue University is an equal opportunity/affirmative action employer.

Geological or Mining Engineer. Geological or Mining Engineer with Ph.D., versatility and capability to integrate with geoscientists, oceanographers and ocean engineers. Permanent full-time teaching/research position with rank and salary open. Send resume and names of three references to: N. W. Ol'Hara, Head, Department of Oceanography & Ocean Engineering, Florida Institute of Technology, Melbourne, FL 32901 (305) 723-3701 x302.

Equal opportunity employer.

Hydrogeologist. Applications invited for a permanent faculty position. The position requires a Ph.D., teaching at graduate and undergraduate levels, supervision of research, and research in area of specialty. Interaction with faculty in surface water hydrology, stable-isotope geochemistry, geophysics, and sedimentary geochemistry is expected.

Candidates should send resume, statement of research interest, and addresses of three references to L. D. McGinnis, Chairman, Department of Geology, Northern Illinois University, DeKalb, IL 60115.

An equal opportunity/affirmative action employer.

Paleontologist. Seek half-time visiting professor for academic year 1981–82 to teach introductory course in paleontology and seminar of own choosing. Appointment is for half-time for entire academic year or full time for fall semester. Ph.D. required. Rank and salary negotiable. Inquiries to: Paul C. Hess, Chairman, Department of Geological Sciences, Brown University, Providence, RI 02912. Deadline for applications is May 31, 1981.

An equal opportunity and affirmative action employer.

Tectonophysics. Seek half-time visiting professor for the academic year 1981–82 to teach course in regional tectonics and seminar of own choosing. Appointment is for half-time for entire academic year or full time for either fall or spring semester. Ph.D. required. Rank and salary negotiable. Inquiries to: Paul C. Hess, Chairman, Department of Geological Sciences, Brown University, Providence, RI 02912. Deadline for applications is May 31, 1981.

An equal opportunity and affirmative action employer.

COURSES

Hierarchical-multiobjective Approach in Water Resources Planning and Management, May 18–22, 1981. Fee $380.

The theme of the 10th annual short course is risk-benefit analysis in the revised Water Resource Council's principles, standards, and procedures. The course, to be held at the Case Western Reserve University, will also include discussions on formulating models and optimization of large complex water and related land resource systems.

To ensure enrollment, send registration forms to the contact by May 1.

Course instructor is Yacov Y. Haimes the first AGU Congressional Science Fellow. Guest lecturers and panelists include Ven Te Chow, David Campbell, Leonard T. Crook, Warren A. Hall, W. Scott Nairns, Wayne S. Nichols, Donald Parsons, Soroosh Sorooshian, and Warren Viessman, Jr.

Contact Short Course, c-o M. A. Pelot, Assistant to Y. Y. Haimes, Center for Large-scale Systems and Policy Analysis, Room 612C, Crawford Building, Case Western Reserve University, Cleveland, OH 44106. Telephone: (216) 368-4492.

SERVICES

Coal Deposits. If you are financing, planning, exploring, drilling, or digging in connection with any form of energy, you need this complete, up-to-date book about the world's coal deposits. Includes production and reserves for mines. Hardcover. 6 × 9 inches, 590 pages. Table of contents, drawings, index, references, 1980. $156. Tetech Associates, Thunder Road, Sudbury, MA 01776, USA.

Meetings

Planetary Rifting Processes

From December 3–5, the Lunar and Planetary Institute in Houston will sponsor a topical conference on the Processes of Planetary Rifting. The conference, to be held in the San Francisco area, will be limited to 60 participants.

Sessions are planned on the speculations on the origin and development of rifts; on the constraints of rift evolution; and on resources associated with rifting.

A letter of application to attend should accompany a brief but specific outline of potential contributions to the meeting, and, if desired, a provisional paper title for potential papers. Send material to Rift Meeting, Projects Office, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, TX 77058. Deadline for applications is May 29. ⊠

MEETING ANNOUNCEMENT
LUNAR AND PLANETARY INSTITUTE TOPICAL CONFERENCE
PROCESSES OF PLANETARY RIFTING

December 3-5, 1981
San Francisco Area

CONVENERS: B.H. Baker and P. Morgen
SESSIONS PLANNED:
1) Speculations as to the origin and development of rifts
2) Constraints on rift evolution - setting
3) Constraints on rift evolution - geological development
4) Constraints on rift evolution - physics and chemistry of the lithosphere
5) Resources associated with rifting
6) Our state of ignorance and its remedy

Attendance will be limited to 60 participants. Send applications to attend with brief, but specific outline of potential contributions to the meeting; include a provisional title if you plan to submit an abstract. Abstracts should be submitted to Rift Meeting, Projects Office, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, Texas 77058, USA. Deadline for applications is May 29, 1981. Further information may be obtained from the above address, or phone (713) 486-2150.

Fluid Dynamics and Geophysics

A 2-week seminar entitled 'Fluid Dynamical Problems in Astrophysics and Geophysics' is being planned for late June or early July by the American Mathematical Society.

Tentatively scheduled are five lectures on astrophysical applications of fluid dynamics, five lectures on geophysical applications of fluid dynamics, and special lectures on geophysics, astrophysics, and mathematics. The two principal series of lectures are intended to formulate the equations of fluid dynamics in special circumstances appropriate to geophysics and astrophysics.

Participants will be assumed to have a basic understanding of fluid dynamics at a first-year graduate student level.

For additional information, contact Norman Lebovitz, chairman of the seminar's organizing committee, at the University of Chicago, Chicago, IL 60637. ⊠

Changes and New Listings

The complete Geophysical Year list appeared in the March 17 *EOS*.

Boldface type indicates meetings sponsored or cosponsored by AGU.

1981

May 4–8 **13th International Liège Colloquium on Ocean Hydrodynamics**, to be cosponsored by AGU.

1982

May 3–7 **14th International Liège Colloquium on Ocean Hydrodynamics**, to be cosponsored by AGU.

Aug. 23–27: Ninth Annual Meeting of the European Geophysical Society, new contact, J. C. Briden, Department of Earth Sciences, University of Leeds, Leeds LS2 9JT, England.

1981

May 8 Symposium Commemorating the 150th Anniversary of the U.S. Naval Oceanographic Office, Bay St. Louis, Miss. (L. W. Alston, Jr., U.S. Naval Oceanographic Office, NSTL Station, Bay St. Louis, MS 39522.)

May 21–23 SCOSTEP IMS Assessment Symposium, Greenbelt, Md. (C. T. Russell, Institute of Geophysics, University of California, Los Angeles, CA 90024.)

June 1–4 First JECSS Workshop, Tokyo, Japan. Sponsor,

Tsukuba University. (Takashi Ichiye, Dept. of Oceanography, Texas A&M University, College Station, TX 77843.)

June 29–July 11 Seminar on Fluid-Dynamical Problems in Astrophysics and Geophysics, Chicago, Ill. Sponsors, American Mathematical Society, Society for Industrial and Applied Mathematics. (Meeting Arrangements Department, American Mathematical Society, Post Office Box 6248, Providence, R.I.)

Aug. 20–21 Second International Symposium on Computer-Aided Seismic Analysis and Discrimination, North Dartmouth, Mass. Sponsors, Electrical Engineering Department, Southeastern Massachusetts University, IEEE Computer Society, IEEE Acoustics, Speech and Signal Processing Society. (C. H. Chen, Electrical Engineering Department, Southeastern Massachusetts University, North Dartmouth, MA 02747.)

Aug. 31–Sept. 2 Third International Colloquium on Mars, Pasadena, Calif. Sponsors, NASA, Lunar and Planetary Institute, Division of Planetary Sciences of the AAS. (Conway W. Snyder, Jet Propulsion Laboratory, Pasadena, CA 91109.)

Sept. 28–Oct. 10 NATO Advanced Study Institute on Chemistry of the Unpolluted and Polluted Troposphere, Corfu, Greece. (W. Jaeschke, Center of Environmental Protection, University of Frankfurt, Robert-Mayer-Str. 11, 6000 Frankfurt/Main, FRG.)

Nov. 9–11 Special Conference on the Mechanical Behavior of Salt, University Park, Pa. Sponsor, Rock Mechanics Laboratory, Department of Mineral Engineering, Pennsylvania State University. (H. Reginald Hardy, Jr., Rock Mechanics Laboratory, Room 117, Mineral Sciences Building, Pennsylvania State University, University Park, PA 16802.)

Dec. 3–5 Topical Conference on the Processes of Planetary Rifting, San Francisco, Calif. Sponsor, Lunar and Planetary Institute. (Rift Meeting, Projects Office, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, TX 77058.)

1982

Jan. 11–14 Symposium on the Understanding of Hydrologic Processes at the Basin Scale, Caracas, Venezuela. Sponsors, Universidad Simón Bolívar, IAHS. (Ignacio Rodríguez-Iturbe, Universidad Simón Bolívar, Apartado Postal 80.659, Caracas 1081, Venezuela.)

Mar. 22–26 International Symposium on Hydrothermal Reactions, Yokohama, Japan. Sponsor, Tokyo Institute of Technology. (Shigeyuki Sōmiya, Research Laboratory of Engineering Materials, Tokyo Institute of Technology, Nagatsuta, Midori, Yokohama, 227 Japan.)

GAP

Oceanology

Volume 19, Number 6, 1979

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Particles and Fields—Magnetosphere

density gradient, wavenumber, plasma β, and flow velocity). The results show the ion acoustic mode is stabilized by the presence of very small amounts of cold plasma. For β<<1, the Alfvén mode is found to dominate over the ion acoustic mode when a sufficiently large background of cold plasma is present. The results applied to the magnetosphere show that the ionosphere plays an important role in determining the type of waves that are generated by a sheared plasma flow and indicate whether the flow boundary is unstable to the Kelvin-Helmholtz instability.
J. Geophys. Res., Blue, Paper 1A0190

5755 Plasma instabilities
SIMULATIONS ON LOWER-HYBRID-DRIFT INSTABILITY AND ANOMALOUS RESISTIVITY IN MAGNETIC NEUTRAL SHEET
Motohiko Tanaka (Geophysics Research Laboratory, University of Tokyo, Tokyo 113, Japan)
Tetsuya Sato

An investigation on microinstabilities in a field-reversal plasma is made by using a 2-D magnetostatic particle code with intent to apply ...

... conditions directly from Maxwell's equations. An alternative derivation, using an analogy to transmission lines, is also given. These equations must then be applied to each perpendicular Fourier component of a source; differently oriented Fourier components propagate differently. The resulting imperfections in guiding will be investigated elsewhere in detail.
J. Geophys. Res., Blue, Paper 1A0181

Physical Properties of Rocks

6110 Elasticity, fracture, and flow
PERMEABILITY AND STRENGTH OF SAN ANDREAS FAULT GOUGE UNDER HIGH PRESSURE
C. Morrow, L. Q. Shi, and J. Byerlee (U.S. Geological Survey, Menlo Park, CA 94025)

The permeability and strength of San Andreas fault gouge from the Cienega Valley was measured under confining pressures up to 2 kbar. The gouge was composed almost entirely of clay minerals, predominantly montmorillonite and mixed-layer clays. Permeabilities ranged between 1 and 10 nanodarcies for confining pressures of a few hundred bars to 1 kbar, and less than 1 nanodarcy for pressures greater than 1 kbar. Permeability was sensitive to confining pressure and differential stress, but did not depend significantly on accumulated strain.

The low strength of saturated clay is often attributed to the buildup of excess pore pressure as the clay is stressed. These experiments, performed under drained conditions where excess pore pressure was not created, suggest that loosely bonded interlayer water in the hydrated clays can generate a pseudo-pore pressure that serves to lower the strength of the gouge. (permeability, strength, fault gouge).
Geophys. Res. Lett., Paper 1L0312

6110 Elasticity, fracture, and flow
SHOCK-INDUCED MICROFRACTURES IN SIX TERRESTRIAL IGNEOUS ROCKS CHARACTERIZED WITH DIFFERENTIAL STRAIN ANALYSIS
R.W. Siegfried (Sullivan Park, Corning Glass Works, Corning, New York 14830), R.G. McQueen, and G. Simmons

Samples from a suite of ten low porosity igneous rocks were shock loaded to low pressures (5 to 10 kbar). The specimens were recovered and analyzed with differential strain analysis (DSA) in order to characterize the microcracks and thus determine the influence of initial sample properties and shock pulse characteristics on shock-induced microcracks. The DSA results reveal the following: The duration of a shock pulse is an important parameter; those samples that had been subjected to a shock of longer duration had a higher post-shock crack porosity. If a sample initially contains a high concentration of cracks closing at a particular pressure, then such a concentration is also present in the post-shock sample in addition to a concentration of cracks closing between 100 and 300 bars which is generally produced by the shock process. The shock-induced cracks in samples with low initial crack porosity close over a wider range of pressures than those in samples with higher pre-shock crack porosity. Neither the grain size nor the high pressure (2 kbar) compressibility of the samples exerted any influence on the post-shock crack distributions. Thus, the distribution of crack porosity with closure pressure of shock-induced cracks reflects only the shock history and the initial crack distribution of a rock. (microcracks, shock waves, ...

Planetology

6510 Atmospheres of Planets
COMPOSITION AND THERMAL PROFILES OF THE JOVIAN UPPER ATMOSPHERE DETERMINED BY THE VOYAGER ULTRAVIOLET STELLAR OCCULTATION EXPERIMENT
M. C. Festou (The University of Michigan, Atmospheric and Oceanic Science, Ann Arbor, MI 48109)
S. K. Atreya, T. M. Donahue, B. R. Sandel, D. E. Shemansky and A. L. Broadfoot

Occultation of the star Regulus –α Leo – by the Jovian atmosphere was monitored by the Voyager 2 spacecraft on July 9, 1979. The absorption recorded in the 910-1200Å range was caused primarily by the H_2-Lyman and Werner bands. These data provide the first complete measurements of atmospheric density and temperature profiles between 330 and 830km above the ammonia cloud tops. The molecular hydrogen density at 380km is found to be $3^{+6}_{-}\times10^{13}$ cm^{-3}, where the atmospheric temperature is 200±50K. The thermal gradient above 830km altitude is found to be approximately 1K km^{-1} to reconcile the stellar occultation data with the Voyager 1 solar occultation data for the exosphere. Both experiments were performed in the equatorial region. The observed temperature gradient in the upper atmosphere rules out inertia gravity wave propagation as the primary heating mechanism; the heating must be caused by one or many of a host of other potential sources such as magnetospheric electrons (soft or hard), Joule heating and even solar extreme ultraviolet radiation. The data do not present a strong argument in favor of an earthlike mesopause on Jupiter. The absorption in the 1250-1600Å range yields volume mixing ratios of methane and ethane of $2.5^{+3}_{-}\times10^{-5}$ and $2.5^{+2.0}_{-}\times10^{-6}$ respectively at a height of 325km above the ammonia cloud tops. An upper limit of 2.5×10^{-6} for the mixing ratio of acetylene has been found at the altitude of 300km. The Voyager infrared data yield mixing ratios of these hydrocarbons and CH_4 deeper in the stratosphere. A study of the density profiles of the hydrocarbons deduced from the stellar occultation data yields a value of the eddy diffusion coefficient at the homopause to be $1.4^{+0.8}_{-0.7}\times10^{6}$ cm^2 s^{-1} in the equatorial region which is consistent with the value deduced from the hydrogen Lyman alpha and helium 584Å emission data. Detailed aeronomical implications of the results are discussed elsewhere (Atreya, et al., 1981).
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6510 Atmospheres of planets
SPUTTER-EJECTION OF MATTER FROM IO.
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A flux of low energy S ions incident on Io is estimated to provide ~5×10^{10} S atoms cm^{-2} s^{-1} to the S torus from sputtering of a dayside atmosphere with an exobase at a few hundred km. If Na and K are present in the atmosphere at a concentration level of 1%, the corresponding sputtering rates are calculated to be a few times 10^{8} cm^{-2} s^{-1}. Sputtering can also remove heavy ...

Seismology

... infer that, at least in the upper 150 km depth range, the descending Nazca plate is contorted rather than torn. (seismicity, focal mechanisms, geometry).
J. Geophys. Res., Red, Paper 1B0368